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The Assopos Viaduct, Greece.

During the past summer there has been opened in Greece a new railway line between Piraeus, on the south, through Demirli to the Turkish frontier on the north. The line, of standard gage, goes through a very rugged country so that it was necessary to build a great number of tunnels and bridges, some of which are of the most bold design. Among the bridges perhaps none is so exceptional as a unique structure known as the Assopos viaduct, which is described in "Le Genié Civil," Aug. 14, 1909, p. 289. From that article we have prepared the following account.

At this location, about 125 miles north of Piraeus, between Dadi and Lianokladi, there is a crossing between two tunnels opening on either side of a gorge 330 ft. deep and about 600 ft. wide at grade of tunnels. Before deciding upon the proper sort of a structure to use there the contractor for the line opened a competition among various bridge companies, which was won by the "Société des Constructions des Batignolles," a French firm, and the viaduct was built by this company after its own plans.

The site had many features that controlled the design. The layout of the railway called for a grade of 1.9% and a curvature of 4% between the portals of the two tunnels. This curve required a reduction of the length of spans and an increase of the number of spans, or else an excessive widening of a long span to take in the curve. At the same time the peculiar topographical conditions, notably the very deep gorge, made at least one long span absolutely necessary. Finally, the view in Fig. 2 is evidence enough of the topographical complications and the difficulties of erection that had to be overcome.

FIG. 1. THE ASSOPOS VIADUCT ON THE CHEMINS DE FER HELLENIQUES, GREECE.

The accompanying figures show how the problem was solved by M. Paul Bodin, of the contracting company. The bridge, as designed and as built, comprises a main arch of long span and peculiar design, and five latticed trusses. The three first trusses on the Dadi side are supported entirely on masonry piers, but the fourth truss rests between the third pier and the upper works of the arch and the fifth truss between a corresponding point on the other side of the arch and the Lianokladi abutment. The four trusses make and angle of 3° 10′ with the center line of the roadway on the arch and this line in turn makes an angle of 5° 39′ with the center line of the single truss. Thus, as shown on Fig. 3, most of the curve is taken up on the roadway supported directly on the main arch, which is wide enough to permit the small curvature necessary in its length. How the difficulties of erection were surmounted is shown further below.

Main Arch.

The main arch has a span of 262.5 ft. and a rise of 78.0 ft. It is composed of two arch trussed ribs, hinged at crown and at spring, and placed in two planes inclined 14% inward from a vertical longitudinal plane through the center line of the bridge so as to give additional stiffness due to the spread of the ribs at the base. The intrados of each rib is curved at the haunches but straightens out toward the spring and crown; the extrados is composed of three straight lines, two rising 45° from the springing hinges and the top one parallel to the grade of the bridge.

The arch ribs are riveted trusses made up as shown in Fig. 4. The vertical and diagonal members coming immediately under the supports of the approaching trusses are made of extra section (Fig. 5) to take care of the abutment reaction coming there. Transverse bracing consists of X-bracing in the vertical planes of the upright posts and in the plane of the intrados and of the inclined part of the extrados. The floor members provide bracing for the horizontal part of the extrados.

The floor system is of the ordinary beam-and-girder design, with a ¼-in. solid plate extending over the entire area above the arch proper, to act both as a solid floor and to give additional stiffness. Guard railings of heavy iron are placed on cantilevered beams.

HINGES.—Inasmuch as the pins of the arch are all in a plane perpendicular to that through the center line of the bridge, all of the hinges had to be designed so as to care for the inclination of the arch rib planes. How this has been done is shown in Figs. 6-7. At the crown the hinge consists of two cast-iron shoes bearing obliquely across their face the semi-circular grooves into which fits a 6.4-in. steel pin. These shoes bear against steel wedges driven between the shoe and a plate riveted to the end face of the arch rib truss. At the spring the masonry is faced in parallel plane to the pin and bears a cellular block separated from the stone by a sheet of lead. On this cellular block and separated therefrom by steel wedges is the cast-iron shoe, holding between its two parts a 12-in. hollow steel pin. On top of the upper part of the shoe is an obliquely faced block which carries the base of the arch at its proper inclination.

As an additional precaution to ensure stability, the ribs are anchored down to the masonry at the abutments by the 2-in. anchor rods shown in Fig. 6.

Trusses and Masonry.

The three main trusses are 86 ft. c. to c. of piers and the approach trusses 84.5 ft. long. They are of the lattice type, reinforced with vertical plates at every other panel, and thoroughly cross-braced and latticed. The floor-system on the trusses is practically the same as on the arch.

Each truss has expansion bearings on one end and fixed bearings on the other, but over any one pier all the bearings are either fixed or expansion. The expansion bearings are on Piers 1 and 3 and on the Lianokladi abutment; they are of the ordinary roller-bearing type. The fixed bearings are on the Dadi abutment, on Pier 2 and on the arch end of the arch approach trusses. On the abutment and piers they are made up of simple riveted plates but on the arch a pin between two triangular shaped shoes is used on each side

Fig. 2. The Assopos Viaduct.

(Fig. 5), and the gap to the arch filled with a cantilevered panel.

All masonry piers and abutments were built of coursed ashlar backed by rubble and founded on solid rock.

Method of Erection.

All the steel work on the viaduct was fabricated by the general contractor, the "Société des Constructions des Batignolles," in its shops at Paris. Before sending it to Greece, it was set up in the shops, in order to assure the proper joining of the various pieces. The steel arrived from France via tunnel on the Lianokladi side, and from there was distributed to its proper place on the work by means of the cableway carrier shown in Fig. 9. The first truss on the Dadi side was constructed on falsework, resting on a timber crib, in proper plan and at an elevation slightly above its final position.

The foundations on either side of the viaduct are of a very hard calcareous rock, which was utilized to construct preliminary tunnels or galleries at each end of the bridge, to serve as anchorages for the construction apparatus. On the Dadi side, this gallery was on a slope in the line of the trusses, and on the Lianokladi side it was level and on the axis of the approach to the arch. The anchorages of tie-rods used in erection were attached to transverse beams fixed into the walls of these galleries. Between these beams and the rock were placed blocks of hard stone, which, together with wooden grillage, distributed the load over the softer rock of the mountain. After the first truss was entirely in place, it was attached just beyond the abutment to the tie-rods which carried back to the anchorage in the rock. After this connection was made, the erection of the second truss was started, and a solid temporary connection made over Pier No. 1 between the two trusses. Then the construction of the second truss was continued on the falsework. This process was continued through the three trusses to Pier No. 3, a solid temporary connection being made between all the trusses at each of the piers. For the fourth truss, the first eight panels only were riveted up, and only a portion of the lateral members placed; however, the first panel was rigidly connected with the third truss.

This portion of the fourth truss was utilized in the construction of the arch ribs. At the foot of the two heavy arch abutments on the Dadi side was constructed a small scaffolding intended to support the hinges and the first few panels of the arch truss. Upon this scaffolding the hinges were erected, and the truss through the first two panels, all of the cross-bracing and laterals placed up to that point. From that point there was built a heavy tie-rod, attached at its upper end to the first panel of the fourth truss and at its lower end to the arch rib. This lower connection was somewhat complicated, because it involved an inclined saddle so that the arch ribs might rest at their proper transverse inclination. This tie-rod once in place, the erection of the arch rib contihued without farther falsework to the end of the inclined portion of the arch truss. The whole weight of this portion of the erection came, of course, upon the tie-rod to the fourth truss, and partially upon the small scaffolding at the abutment.

To avoid any overbalancing of the cantilever portion, the springing line at the extrados was temporarily heavily loaded. At the upper end of the inclined truss there was then placed a horizontal tie-rod reaching back to the first panel of the fourth truss, where the inclined tie was already in place. The load was then taken off of the inclined tie-rod and thrown entirely on the horizontal rod, first seeing that the trusses

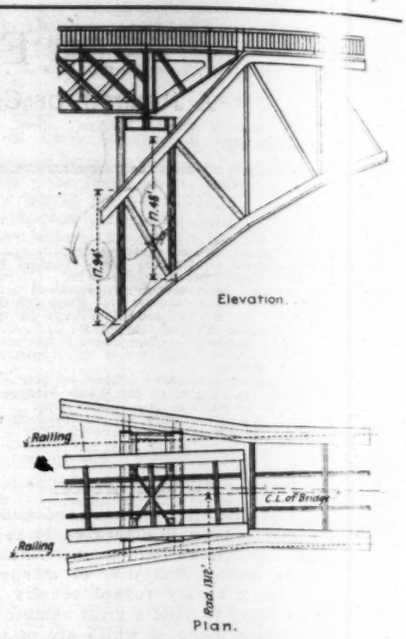


Fig. 5. Details of the Connection Between Approach Truss and Arch, Assopos Viaduct.

through which the pull went back to the anchorage were firmly in place and not likely to be disturbed by the load of the arch rib. This stage of the progress is very well shown in Fig. 8. Construction of the arch rib then continued to the crown.

Only such cross-bracing as was necessary to hold the rib in place was erected at this time. The rib on the Lianokladi side was constructed in practically the same manner, except that the

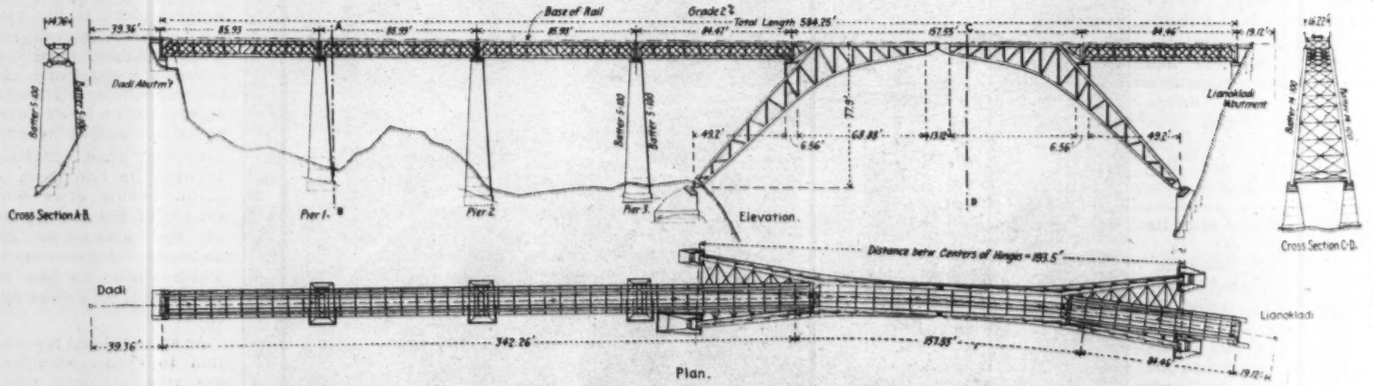


FIG. 3. PLAN AND ELEVATION OF THE ASSOPOS VIADUCT.

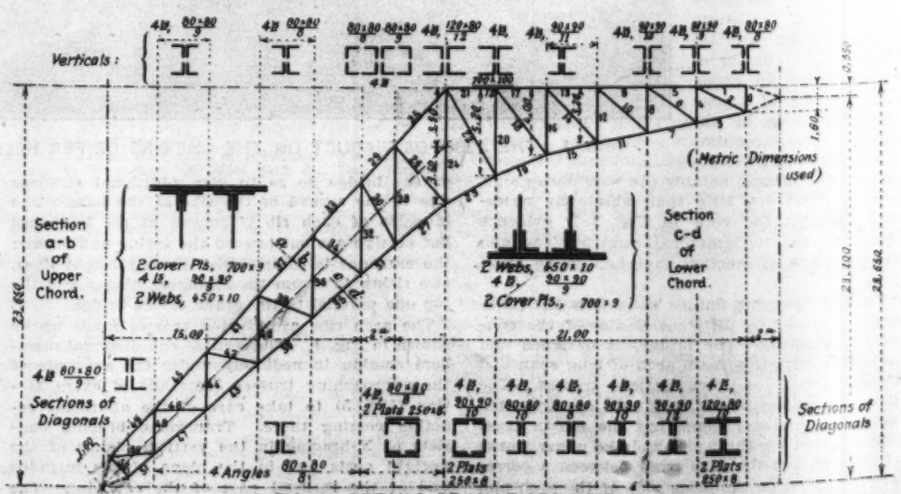

Verticals :
(Metric Dimensions used)
Section a-b of Upper Chord.
2 Cover Pls. 700 × 9
4 Bs. 80 × 80 / 9
2 Webs, 450 × 10
Section c-d of Lower Chord.
2 Webs, 650 × 10
4 Bs. 80 × 80 / 9
2 Cover Pls., 700 × 9
15.00
21.00
Sections of Diagonals
4 Angles 80 × 80 / 11
2 Plats 250 × 8
Sections of Diagonals

FIG. 4. DETAILS OF HALF ARCH RIB.

horizontal tie-rod rested on a scaffolding which was used afterward in the erection of the truss approach on that side.

In keying the arch, a multiplied screw balance, such as is shown in Fig. 10, was used. This device consists of a series of balances, A, B and C. The arms of the larger balances, A and B, were made of a number of plates and were immovable; but the arms of the small balances, C, were of 2-in. rods, fitted on one end each with a screw and nut, so that the whole distance AA could be increased or decreased by screwing the nuts on C. This was placed in the middle of the horizontal tie-rods, as shown in Fig. 9, and controlled to a very fine degree the movement of the arch ribs. As soon as they met in the middle, the erecting tie-rods were removed and the floor-system of the arch completed. Then the remainder of the fourth truss was riveted up and finally the fifth truss was erected on the false-work already in place to hold the tie-rod.

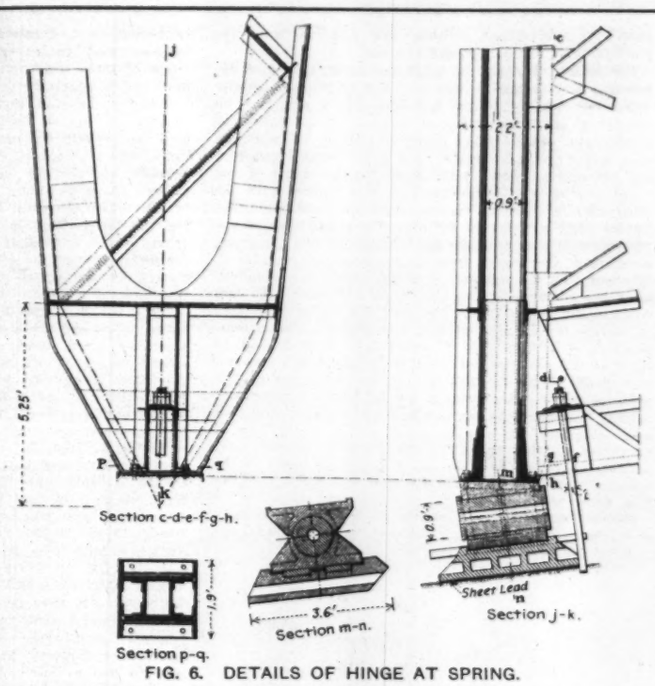


FIG. 6. DETAILS OF HINGE AT SPRING.

Stresses and Quantities.

The designing stresses used on the structure were those prescribed for similar work by the regulations of the French government. The masonry stresses were as follows:

Foundations	8.2 tons per sq. ft.
Masonry in Piers	10.3 tons per sq. ft.
Cut stone under direct pressure from trusses	25.8 tons per sq. ft.

In the entire work the following quantities were used:

Steelwork:	
5 Trusses	200 tons
Arch	209 tons
Extra	22 tons
	440 tons
Masonry	505 cu. yds.
Excavation:	
Erection tunnels	210 cu. yds.
Erection yards (on side hill)	65

The work was started July 2, 1905, and completed Aug. 5, 1906.

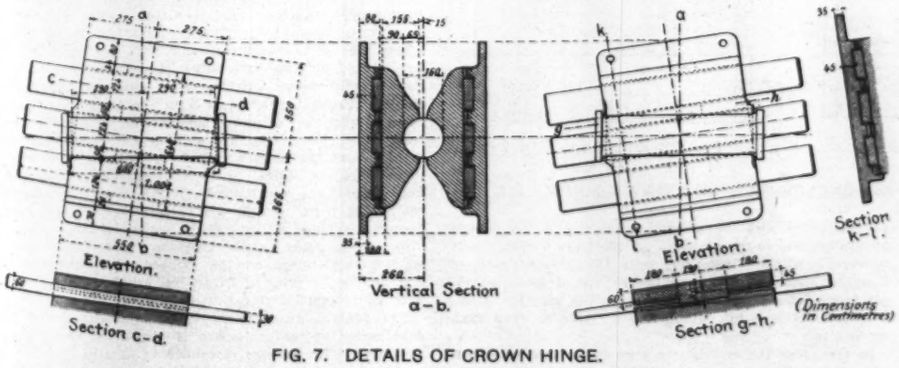


FIG. 7. DETAILS OF CROWN HINGE.

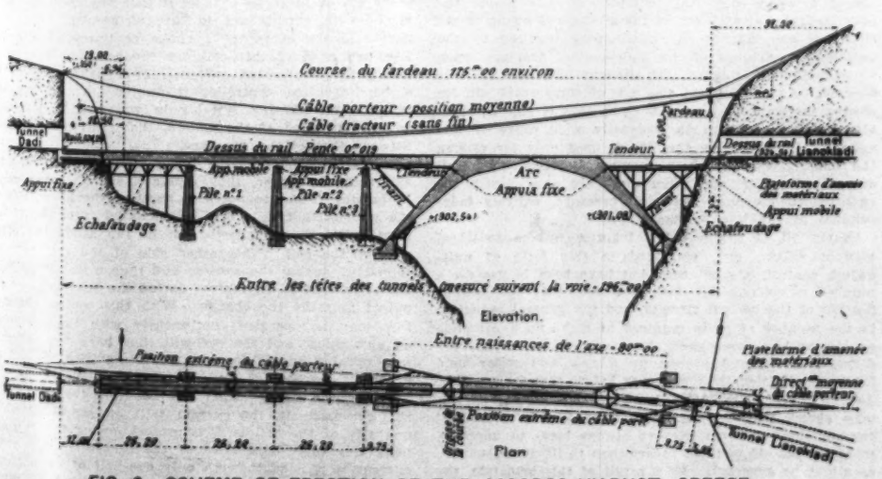


FIG. 9. SCHEME OF ERECTION OF THE ASSOPOS VIADUCT, GREECE.
(Dimensions in metric system.)

Recent Developments in Railway Motor Control.*

By CLARENCE RENSHAW,† Assoc. Am. Inst. E. E.

From the standpoint of the average operator, the value of any part of a car equipment depends largely upon its constructional details. This is particularly true of control apparatus. A rheostatic controller of rugged design, for instance, which could be used for a week without attention would, as a rule, be regarded as far superior to a series-parallel one of a type which happened to be of more delicate construction, and on this account required daily attention. Owing to the fact that the latter is based upon a more correct principle than the former, however, the power saved by its use might easily overbalance the extra inspection. Some men, in such a case, might even be inclined to criticize the series-parallel principle, merely on account of the faulty details of construction in the particular type of controller which they had tried.

The control of railway motors, as practiced to-day, depends upon some half a dozen or more fundamental principles, such as the magnetic blow-out, the series-parallel connection, the power-operated switch with indirect control, and so on, and during the period which may

Fig. 8. View Showing Half Arch Rib During Erection.

reasonably be included in the scope of this paper, there have been no new developments of this sort to chronicle. In the perfecting of details and the production of new forms, sizes, and modifications of apparatus, however, many things of interest and importance have been done.

UNIT-SWITCH CONTROL.—The most important developments of the latter sort have been in the unit-switch system of train control. Designed originally for elevated and electrified steam-railroad service, this control has heretofore been made for use with automatic acceleration only, and with the power for operating the control circuits derived from a small storage battery on the car.

In this system of control it is only necessary for the motorman to place the handle of the master controller in the series or the parallel position and the switches will then close automatically, under the direction of a current-limit switch in the motor circuit, and cut out the resistance until the full series or full parallel position is reached. This effect is accomplished by making the

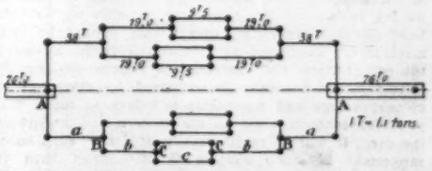


Fig. 10. Multiplying Screw Balance Used in Erecting Assopos Viaduct.

master controller merely close the magnet-valve circuit of the switches required for the first step, and arranging other circuits so that the closing of these switches establishes new circuits to the magnet valves of the switches for the second step, and so on, by means of auxiliary contacts or interlocks mounted on switches.

This system of control is remarkably simple, considering the results that it accomplishes. About a thousand or more of these equipments are in use on a number of large roads throughout the country, including the Long Island R. R., the Brooklyn Rapid Transit Co., the Metropolitan and the South Side Elevated R. R. in Chicago, the United Railways & Electric Co., of Baltimore, the

*Appendix to the report of the Committee on Equipment, presented at the annual meeting of the American Street and Interurban Railway Engineering Association, Denver, Oct. 4.

†Westinghouse Electric & Manufacturing Co., Pittsburg.

Pacific Electric Railway Co., of Los Angeles, and the Connecticut Co., where they are giving excellent satisfaction. Many operators, however, have hesitated in adopting the system for use on single cars or two-car trains, with equipments of moderate size, because of the apparent complications due to the automatic features, and on this account a much simpler form of unit switch control has recently been developed for use in such cases.

In the simplified form of unit-switch control, the various connections between the motors and the resistances are made by means of seven or more (according to the size and number of the motors) pneumatically operated switches assembled together in a "switch group," and one pneumatically operated "reverser." Each switch is connected to the piston of a pneumatic cylinder, and normally held open by means of a powerful spring. The opening or closing of the switch is regulated by means of a magnet valve, connected to the cylinder, which admits compressed air when the circuit of the magnet is closed, and releases it when the circuit is broken. The reverser is moved to one or the other of its two positions by admitting air to one or the other of two cylinders similar to those on the switch group.

The supply of air for closing the switches is obtained from the main reservoir of the brake system, which is piped to an air chamber in the switch group, through suitable cocks and valves, together with an emergency storage tank for operating the car in case of failure of the compressor. The small amount of power which is required for operating the magnet valves is obtained from the trolley through a "control resistance," and its application is governed by a master controller at each end of the car. A direct wire from the magnet valve of each switch, or combination of switches, is carried

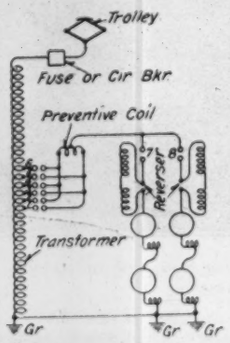


Fig. 1. For Small Motors.

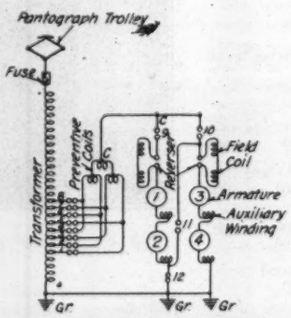


Fig. 2. For Large Motors.

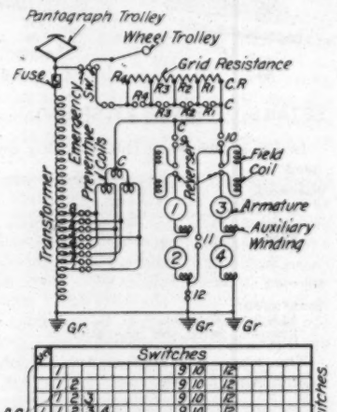


Fig. 3. For Operation on Both Direct and Alternating Current.

FIGS. 1, 2 AND 3. CONTROL DIAGRAMS FOR SINGLE-PHASE RAILWAY EQUIPMENTS.

to the master controllers, and these are so arranged that when the handle is moved to any notch, the circuit of the magnet valves of the several switches corresponding to that notch is closed and the switches are thus operated. By moving the master controller from notch to notch, therefore, the motorman starts and controls the motors in exactly the same way as with the ordinary hand-operated controller, except that instead of being mechanically connected to a revolving drum, located on the car platform and carrying the various contacts, the handle which he turns is connected by means of the magnet valves and pneumatic cylinders to much more powerful contacts close to the motors and underneath the car. It will be readily appreciated that such an arrangement is much simpler to understand than the automatic form, and as a matter of fact, the various circuits with this form of control can be as easily traced out as those of the ordinary drum-type controller.

The various circuits are carried to a multi-point train line receptacle at each end of the car, so that the circuits on two or more cars can be connected together by inserting a suitable jumper between adjacent receptacles, and the corresponding switches on each car can then be operated simultaneously by moving a single master controller.

Instead of the usual circuit breaker above the motorman's head, a small plunger is so arranged on the side of the switch group that when the current exceeds the desired amount, the plunger is drawn in by the magnetic action of the blow-out coil at the end of the group, and by its movement opens the circuit to the magnet valves of the various switches, thus opening the switches. After having been opened in this way, the switches cannot be closed again until the master controller has first been returned to the "off" position. All of the main-circuit contacts, therefore, corresponding to both car platforms and the greater reliability of the control apparatus, due to the powerful action of the pneumatically operated switches, together with the greater ease of handling the controller, and the saving of space on the platforms, affords sufficient reason for the adoption of this system of control for equipments of large or even moderate size.

In arranging the switches in a group, a blow-out coil is placed between each two switches, directly beside the jaws, and also at each end of the group, and owing to the short air gap, due to the small space required by the switches, on account of the high contact pressure used, an exceptionally intense and efficient blow-out effect is secured. As a result of the use of compressed air for closing the switches also, this equipment is able to operate satisfactorily with an unusually wide range of line voltage. Current from the line is used only for closing the magnet valves, which require an extremely small amount of power, and when these are once closed, the switches then operate with full pressure, entirely independent of the line voltage.

Nearly all of the essential features of the switches, magnet valves, etc., employed in this form of unit-switch control, are not new, but have been in use for a number of years. We feel, however, that the simplification of the control circuits, and the general reduction in the number of parts required to make up a complete equipment has now placed the apparatus on an entirely different basis, and opened up a new and wider field for its application than was ever before thought possible.

AUXILIARY CONTACTOR OUTFITS.—General experience shows that the introduction of a new method of accomplishing a given purpose always leads to improvements in the old method, rather than to its abandonment, as might be expected. As a result of this principle, the more common use of indirect control has led to various improvements and special features in the [illegible] direct or hand-operated controllers.

One of these improvements is the use of an auxiliary unit switch contactor in connection with the controller, for reinforcing and protecting it. To accomplish this purpose a single pneumatically operated switch is mounted beneath the car, and the circuit to its magnet valve closed or opened by means of a pair of auxiliary contacts, operated by the main controller drum. By arranging these auxiliary contacts so that their circuit is broken before the main power circuit, the duty of breaking the latter may be transferred from the controller drum to the contactor; that is, from the platform to the under side of the car. This leaves to the controller merely the function of cutting resistance in or out of circuit, and the making of the series or parallel connections.

The interval of time between the breaking of the auxiliary circuit and the breaking of the main circuit on the controller drum, however, is so small a fraction of a second that it is ordinarily impossible to be absolutely sure that the circuit will be opened by the contactor rather than by the drum, if the controller is operated in the ordinary way. This point can readily be cared for, however, and the opening of the circuit by the contactor assured, by the use of a special controller handle, so arranged that, ordinarily, merely the auxiliary circuit is broken by the controller drum and not the main circuit. In case it is desired to do so, however, pressing a latch on the handle allows the drum to be moved to the usual "off" position, where the power circuit is broken on it.

MULTIPLE UNIT OPERATION WITH HAND-OPERATED CONTROLLERS.—In cases where double-motor equipments are used instead of quadruple, and especially with single-end cars, two-car multiple-unit train operation may readily be arranged for with ordinary hand-operated controllers. To secure this, it is merely necessary to use a four-motor controller and resistance on the cars instead of a two-motor one, together with suitable receptacles and jumpers for connecting the two motors on the rear car to the controller on the forward one. When this is done the two-car train then consists of a standard quadruple equipment with two of the motors on one car, and two on another, or, to use a term which is now becoming common in connection with electric locomotives, the two-car train really consists of an "Articulated" car. The trolley on either car can be used and either car may be operated singly, if desired, or as a No. 1 or a No. 2 unit of the train.

With double-end cars no simple arrangement can be made so that the cars will be interchangeable, but similar operation can be secured by providing a certain number of head-end cars and a similar number of rear-end cars, in which case only the former need have four-motor controllers. This latter arrangement, or one very similar to it, has been used in several places.

CONTROL OF SINGLE-PHASE RAILWAY MOTORS.—The use of a transformer on each car, from which any desired voltage or number of voltages, for application to the motors can be easily obtained, makes the single-phase system as ideal from the control standpoint as it is from that of power supply. Variable connections from series to parallel are entirely unnecessary in this system, and the motors may be permanently connected in parallel, in series, or in series-parallel, as desired, and simple and economical control secured by merely connecting them to different voltage taps on the transformer. Owing to the self-induction of such motors, also, which tends to minimize the current fluctuations, smooth acceleration can be secured with comparatively few notches, a total of five being usualy sufficient even with equipments aggregating 400 HP. or more.

The general arrangement that has been adopted for equipments of moderate size is shown by the diagram in Fig. 1. The motors (arranged in parallel if only two are used, or in series-parallel if four are used, for convenience in cutting out in case of accident) are connected to the center of a choke or "preventive" coil. The two ends of this coil are connected by means of pneumatically-operated switches, or by the contacts of a hand-operated controller if desired, to taps on the transformer differing suitably in voltage. The voltage actually received at the motors, then, will be the mean between that of the two taps.

In starting the car, the lower contact is closed first and then the upper, thus giving a smooth, easy start. In passing from one notch to another, the lower side of the preventive coil is first disconnected from the transformer and then connected to the tap above the other side of the coil. This other side of the coil remains connected during the process and thus maintains a supply of current to the motors during the brief interval required to make the change. With this control the motors may be operated continuously with the controller on any notch, and the car will thus have five different free running speeds for any given condition of load or grade.

During the change from one notch to the next, with this arrangement, the current falls off somewhat while one side of the coil is disconnected, owing to the comparatively high impedance of the preventive coil when current is passing through only one-half of its winding. This falling off may be considerably reduced by using

three cars connected, as shown in Fig. 2, and this arrangement is employed on large equipments.

The same pneumatically-operated unit switches that are used for direct-current work are employed for making the above connections, and they can, if desired, be so arranged that the magnet valves may be operated by alternating current from the transformer. For such equipments, however, particularly where multiple-unit trains are to be employed, the use of a small storage battery for operating the magnet valves offers certain advantages, among which may be mentioned the ability to control pneumatically-operated pantagraph trolleys throughout an entire train simultaneously.

Where single-phase cars are required to operate at times on direct current, the connections shown in Fig. 3 are used. As far as alternating-current operation is concerned, these connections are the same as those shown in Fig. 2, with additional switches and resistance for direct-current operation.

On such equipments, the control circuits, from the master controller to the various magnet valves, are first led through a "change-over switch" which connects them to one or the other of two sets of magnet valves, according to its position. This change-over switch is controlled by two relays, one connected to the transformer and one to the direct-current trolley circuit, in such a way that when the alternating-current trolley is receiving alternating current, the change-over switch will automatically take the position for alternating-current operation, and when the direct-current trolley is receiving direct current, it will then take the position for direct-current operation. With this equipment, therefore, operating the master controller in exactly the same way closes one, or the other set of switches according to whether the car is operating on alternating or direct current, and it is merely necessary for the crew of the car to see that the proper trolley is on the wire.

All of these various control schemes as applied to different sizes of motors have been used in service on various roads, and all have been remarkably successful and satisfactory. As an instance of this, the master mechanic of one of the large single-phase roads stated not long ago that he believed he was having less than one-half of the trouble with his control apparatus than he would have had with hand-operated direct-current controllers.

A New and Efficient Jet Condenser.*

The improvements in various types of condensing apparatus, making possible the high degrees of vacuum needed in steam-turbine work, have been noted from time to time in this journal. That this improvement has been broad and general is seen when each manufacturer's progress is duplicated by others through distinctly different advances.

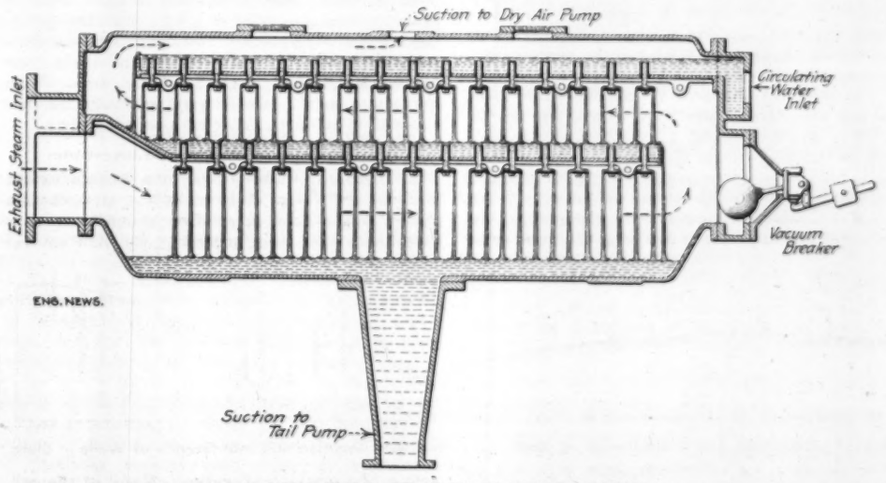
In surface condensers it has been a problem largely of increasing the heat transmission per unit area of cooled tubes. With new jet condensers it has been more a problem of securing an intimate mixture of cooling water and exhaust steam, that the water before leaving may be heated as nearly as possible to the temperature of the steam. This is desirable in decreasing the amount of injection water that must be pumped. There is an added advantage should the injection water be run through a cooling tower, on account of the increased temperature difference between the water and the air. There is a third advantage in decreasing the amount of injection water through the lessened amount of air brought in only to be discharged by the air pump.

With both surface and jet condensers for the high degrees of vacuum now demanded, better air pumps were demanded. This need has been supplied by various apparatus placed on the market within the last year, as has been noted.

An improved jet-type condensing chamber has now been designed by the Wheeler Condenser and Engineering Co., of Cateret, N. J., and is shown in section in the accompanying figure. Water is introduced at the upper right-hand corner into an extended trough or pan, from which it overflows through numerous short tubes, and also at the far edge, falling into a second and similar pan provided with similar overflow pipes and a saw-tooth weir, and finally falling into the lower part of the shell. From here it flows to the barometric column or to a pump serving to overcome the atmospheric pressure.

The exhaust steam enters through the opening at the left, passes horizontally across through the shower of water, ascends to the second level, passes to the left through the upper shower, and finally all that is left of the steam vapor together with the air, and other gases, passes horizontally to the right, and over the entering and coldest water at the top to the dry-vacuum pump suction opening in the uppermost part of the shell. It will be noted that the cross section of the passage traversed by the steam continuously diminishes as the volume of steam is reduced by condensation. In this way an approximately constant velocity of steam and uncondensable gases is maintained. The heavier air is thus positively swept along toward the vacuum pump and at the moment of leaving is in contact with the coldest water entering. This is essential, as has been variously pointed out,* to decrease the amount of water vapor normally held in solution by the outgoing air and to decrease thereby the volume of gas and vapors drawn off. This decreases the cost of vacuum-pumping of course.

At the right of this figure, will be seen a float controlling a vacuum-breaking valve. In case the water level should rise abnormally in the shell, due possibly to stoppage of the circulating pump, this will break the vacuum and the inflow of water will cease, since the circulating water is siphoned up to the condenser head from a lower level. The exhaust steam would escape through a relief valve. The use of this condenser head in commercial practice is shown in the accompanying table. The exhaust came from a 1,000-KW. Parsons turbine in a street-railway power plant. The injection water was taken from a nearby creek. An air pump was used with which it had been possible to hold a vacuum within ½-in. of barometric pressure height. On the day of the test, the barometer registered 29.9 ins. and the street-railway load on the turbine varied from 100 to 110% full load. Temperature readings were taken by thermometers in the exhaust line and in the hot well. The vacuum readings were taken from a mercury column at the condenser.



A NEW TYPE OF JET-CONDENSER HEAD.
(Designed by the Wheeler Condenser and Engineering Co., Carteret, N. J.)

RESULTS OF TEST OF "RAIN-TYPE" JET-CONDENSER HEAD.

Built by Wheeler Condenser & Engineering Co., of Carteret, N. J.

Vacuum, actual ins.	Absolute pressure, ins., mercury.	Temp. of Exhaust. deg. F.	Injection water. In. deg. F.	Injection water. Out. deg. F.	Temp. diff. between steam and injection water.
28.65	1.25	85.5	44	85	0.5
28.7	1.2	85.	44	85	0.0
28.75	1.15	83.5	44	85	0.5
28.7	1.2	85.	44	83	2.0
28.75	1.15	83.5	44	80	3.5
28.75	1.15	83.5	44	81	2.5
28.65	1.25	85.5	44	80	5.5
28.55	1.35	88.5	44	87	1.5
28.75	1.15	83.5	43	79	4.5
28.75	1.15	83.5	43	76	7.5
28.6	1.3	87.	43	82	5.0
28.6	1.3	87.	43	82	5.0
28.7	1.2	83.	43	82	3.0
28.65	1.25	85.5	43.5	82	3.5
28.75	1.15	83.5	43.5	83	0.5

The Interference of Wells.

By FREDERICK G. CLAPP.*

The conditions under which deep wells affect other wells in the vicinity drawing water from the same formation are not commonly well understood. Many persons suppose that because wells are situated several hundred feet apart they necessarily draw water from separate reservoirs having no connection and that the pumping of one does not affect the other. Nothing could be further from the truth. It is a common experience to find that the yield of a well has been influenced by the construction of a new well in the vicinity.

An interesting study might be made of the effect of neighboring wells upon one another, and such a study would be of practical value to the inhabitants and to persons desiring to sink wells in particular regions, and furthermore it would increase the scientific knowledge of the conditions under which underground waters exist. The facts presented in this article do not pretend to be the results of any extended investigation of the subject, being only scattering data collected at different times by the writer, and published here in the hope of contributing to a better understanding of the conditions. A part of the data were secured while conducting investigations on other subjects for the United States Geological Survey.

Mode of Occurrence of Underground Waters.

In order to understand the conditions affecting wells drilled in proximity to each other, it is necessary to have in mind the various geological conditions under which water exists below the surface of the earth. Well water does not come from vast inexhaustible subterranean lakes, but, originating in rainfall, it reaches the shallow or deeply-buried strata by absorption, percolating and slowly descending through the more pervious formations and passages to the ground-water level (water table).

Water which occurs in sands, gravels and other superficial deposits is generally held in the pores, or spaces between the pebbles or smaller particles. In certain types of solid rocks, as some sandstones, conglomerates and very porous limestones, water occurs in the same way, saturating the entire rock below the level of the water-table. Other rocks, however, are so hard, compact and close-grained, that the amount of water held in the pores is very minute. In such rocks practically all the water is held in various forms of crevices, cavities and fissures. In slates and argillaceous schists considerable water is held in the bedding and cleavage planes. In granites, gneisses, slates, schists and most crystalline rocks the largest amounts are held in joint-cracks (fissures which cut the rock in various directions). Where rocks have been faulted,

*From information furnished by the G. H. Gibson Co., Tribune Bldg., New York City.

*Engineering News, Aug. 19, p. 205.

*Consulting Geological Engineer, 610 Fitzsimons Bldg., Pittsburg, Pa.

—that is, where one wall of a fissure has moved up or down or horizontally with reference to the other wall,—water may be abundant in the fissure, as evinced frequently by lines of springs, which sometimes follow the fault where it cuts the surface. In limestones large amounts of water occur in solution cavities which have been dissolved by slow percolation of water. The interference of wells has been observed in nearly all the principal classes of rocks.

Interference of Wells in Sand and Gravel.

For the purpose of technical description, sands and gravels, as well as all surface deposits of the earth, even though they may be unconsolidated, are considered as "rocks." Sand and gravel deposits, although commonly thin, are frequently several hundred feet in thickness. Such is true over large areas in northern Ohio, Indiana and Illinois, southern Michigan, locally in the Atlantic States, over large areas of the Coastal Plain in the South, and at many scattering localities in the plains of the West. In such formations the water is held in pores, and saturates the entire mass below the level of the water-table.

Fig. 1 represents a section through a deposit of sand and gravel, showing the entire mass saturated up to the level of the water-table (T-T_1). W and W_1 are drilled wells. When W is pumped the water is drawn down throughout a small area about the well, forming a dry inverted cone-of-depression (A-A_1-A_2). With harder pumping the cone will be depressed to B-B_1-B_2. At this stage it will intersect the well W_1 at the water level, B_2, and any further draft on W will depress B_2. If W_2 should be pumped, a second cone-of-depression (M-M_1-M_2) will be formed.

The ease with which a well affects surrounding wells is dependent on the depth of the wells below the water table, the capacity of the pumps, the degree of porosity of the deposits, the number of

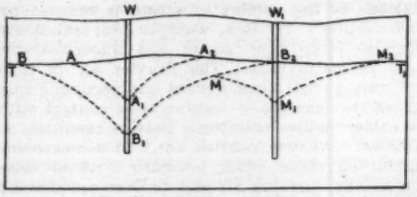


Fig. 1. Condition and Interference of Wells in Sand and Gravel.

accelerates the decline of head in neighboring wells.

Examples are numerous. During examinations by the writer of water supplies at Newcastle, Ind., it was found that when the pumps of the city water-works were in operation, the flow and head of water from a number of deep wells in gravel within a quarter of a mile from the pumping station were greatly decreased. In examinations in the Coastal Plain region of southern California, Mendenhall found that all wells in an immediate neighborhood were mutually dependent, and interfered to a greater or less extent.

Interference of Wells in Limestone.

In limestone, water exists to a certain extent in pores and along joint cracks and stratification planes, but mainly in solution channels or cavities which have been formed by the slow solvent

Fig. 2. Condition and Interference of Wells in Limestone.

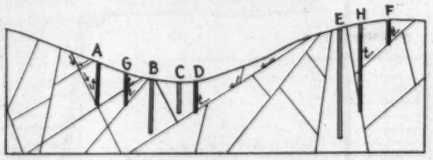


Fig. 3. Condition and Interference of Wells in Slate.

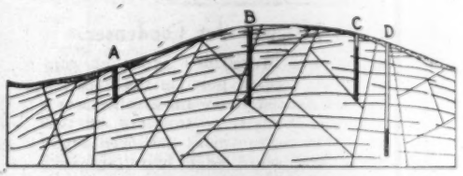


Fig. 4. Condition and Interference of Wells in Crystalline Rock.

wells, and their distance apart. In a broad sense it can be said that every well drawing water from a particular formation, whether flowing or pumped, affects every other well drilled into the same formation. However, in wells that are widely separated, the effects are so slight as to be indeterminable. Slichter has computed (19th Annual Report, U. S. Geological Survey, Pt. II., 1899, p. 374), that the interference of two 6-in. wells penetrating the same water-bearing stratum is 38.33% if the wells are situated 5 ft. apart, but only 6.23% if they are 100 ft. apart. As the number of wells increases, the percentage of interference increases also. As determined by Slichter, three 6-in. wells 5 ft. apart on a 10-ft. line will have 55% of interference, while the same wells if placed 100 ft. apart on a 200-ft. line will have only 30.9% of interference.

That wells in sand and gravel do have an appreciable, and at times a serious, effect on each other, is illustrated by many artesian well developments. The universal experience in basins of flowing artesian wells is that after a time the head and volume of the water decrease. This is due to many causes, including deforestation, waste of water, drainage by ditching and tiling, overdevelopment of the supply, underdrainage by quarries, deficiency of rainfall in certain years, and leakage through corroded or improperly-fitted casings. Whatever the direct cause may be in any particular case, the decrease of head, when the entire basin is affected, indicates that the draft on the wells, by natural flow or pumping, or both, exceeds the inflow from other portions of the porous stratum. The excessive draft may be due, as in many known instances, to careless neglect by which wells have been allowed to flow to waste when serving no useful purpose, it may be due to a too great number of wells, or to an excessive draft on certain wells.

A well or a group of wells may be influenced by a single well situated in a more favorable position with reference to the source of supply, or at a lower level. In all artesian basins the wells sooner or later decline to the stage where they must be pumped, and the effect of pumping

action of slightly acid waters. Many of the cavities, but not all of them, have been formed through the enlargement of joints; therefore they center about the intersection of fracture systems. Small solution channels, a few inches in width, and frequently many hundred feet long, can be seen in quarries of the Niagara limestone formation in Ohio and Indiana, in the Joplin limestones of Missouri, in the Vicksburg limestone of Florida, and in fact in nearly all limestone districts, but passages of cavern size are found only in certain limestones. The best example in this country is the Mammoth Cave of Kentucky. In this cave some of the passages are 20 to 70 ft. high and 50 to 100 ft. broad. In Florida "natural wells" several inches or feet in diameter and a score or more feet in depth are frequent, and have been formed in a similar way.

In a limestone district, therefore, it may be expected that supplies of water below the water table will be of considerable volume, and such is generally the case. Wells in limestones are seldom failures, if deep enough. Fig. 2 is a section of a limestone formation into which three wells have been sunk. This shows how two wells many hundred feet apart may interfere with each other.

Wells W and W_1 tap the same water-bearing passage, while W_2 taps an entirely separate passage. Hence, if W be pumped sufficiently hard and continuously it will decrease the capacity of W_1, while W_2 will remain unaffected. In some limestone districts the supply of water is so great that no amount of pumping on a well will affect the water level in the rock.

The writer has in mind the case of an artesian well in the City Park at Marion, Ind., which draws its water from an open passage in the Niagara limestone. On Sundays this is a flowing well of many gallons per minute, but on week days the flow does not reach the surface, and it becomes necessary to insert a pump, which is kept there by the authorities for the purpose. The affecting agency here is a paper mill over half a mile distant, which apparently taps the same water-passage as the park well. No other cases of the sort were found in the vicinity, but they may exist.

Interference of Wells in Slate.

Examples of the interference of water wells in slate are less numerous, partly because of the small lateral extent of most slate areas, and partly owing to the prevalent belief that little water exists in slate. The latter is a delusion, as proved by the writer in examinations of underground waters in Maine and other States (Water Supply Paper No. 223, U. S. Geological Survey, 1909, pp. 33-35), which have shown that the hard, compact and close-grained types of slate commonly contain more water than any other formation except sand, gravel, sandstone and limestone. About 90 per cent. of drilled wells in slate are successful. The water is held to some extent in cleavage cracks, but mostly in joints, which traverse the rock in all directions. They can commonly be grouped roughly in two or more systems, according to direction.

Fig. 3 is a section showing the mode of occurrence of underground water in slate. This figure illustrates how the crevices are comparatively local in horizontal projection. Hence, two wells, in order to interfere, must generally be within a few feet of each other, and must tap the same joint crack or an intersecting one. Wells F and H will interfere with slight pumping, wells A and G may interfere if pumped unusually hard or continuously, well D will not be affected by any other well, while B, C and E are wells in which no joint crack was struck and hence in which no water was found.

A few examples of slate wells which interfere with each other have been seen in the field by the writer. All of these are situated in the State of Maine. One of them, at Foster's Dyehouse, in Portland, drilled in 1886, is 140 ft. deep, and penetrates several water-veins. When a second well was drilled about 600 ft. distant the water level of the dyehouse well was depressed about 3 ft.

A second instance was at Dark Harbor, Islesboro', Maine, where, in 1901, Charles Pendleton drilled a well to a depth of 88 ft. At a later date a well was sunk 16 ft. distant, on the Allen property, and in half an hour after water had been struck in the Allen well the yield of the Pendleton well diminished so seriously as to suck air. The Pendleton well was then deepened to 140 ft, and encountered a large volume of water which supplied both wells. In 1906 water would still rise to within 5 ft. of the surface in both of them, but the greater part of the water in Allen's well was supplied from the natural connection with Pendleton's. The rock at this place is much broken up, and in the Pendleton well the drilling tools were very nearly lost in a joint crack at a depth of about 80 ft.

On an island in Portland Harbor, Maine, the Peaks Island Water and Light Company in 1905 drilled a well 203 ft. deep, within a very few feet of a well which they had drilled seven years previous to the same depth. The rock is a schistose form of slate. The wells were found to communicate, and can be pumped together at a rate of 75 gals. per min., day and night.

Interference of Wells in Crystalline Rocks

Geologically the crystalline rocks, such as granite, diorite, syenite, gabbro, basalt, etc., have no similarity with slate, but the fact that they are

cut up by joint cracks in much the same way, causes the underground water to occur under similar conditions. The chief difference, illustrated in Fig. 4, is due to the existence of concentric, or sheet jointing, in crystalline rocks, in addition to the vertical and diagonal joints. The concentric joints are approximately parallel to the surface, and contain small quantities of water. They have been formed by alternate expansion and contraction of the upper zone of the rock owing to changes of temperature. These joints are generally only a foot or two apart near the surface, but many feet apart at greater depths.

Crystalline rocks, like slate, are popularly supposed to contain no water; but this supposition also is a fallacy, for to a depth of 200 ft. or more, granite will yield moderate supplies, which are held in the joint cracks. This water is uniformly of excellent quality. About 90% of wells drilled into granite are successful.

In J. C. Rogers' granite quarry, near Stonington, Maine, two wells, 50 ft. apart, were drilled to depths of 94 and 279 ft. These wells are connected by a natural crack about 60 ft. from the surface, and by pumping the 94-ft. well, water can be drawn from both, the combined capacity being 60 gals. per min. The wells of the Southwest Harbor Water Company, on the Island of Mount Desert, Maine, also in granite, are situated 36 ft. apart, and are connected 90 ft. from the surface.

Pollution of Water-Bearing Strata by Oil-Well Waste.

Many examples of the channeled and porous nature of some deeply buried rocks are found in the oil regions. In parts of Pennsylvania, Ohio, Indiana, Illinois and other States, irretrievable damage has been done to certain water-bearing strata by improperly allowing salt water to rise from below and enter fresh water-bearing rocks. The results have been so disastrous that laws have been enacted in some States to prevent the continuance of pollution by oil waste. Laws in several States require that abandoned holes be properly plugged.

As a rule, the deep well waters are under greater head than are those nearer the surface, and where these waters are oily or briny and rise by artesian pressure into a higher stratum the waters in this stratum are seriously injured. Such is the case in parts of the oil regions of northeastern Indiana, where an excellent quality of water is obtained from the Niagara limestone, a formation ranging from 250 to 500 ft. thick. Over 500 ft. deeper, and separated from the Niagara by shale, lies the Trenton limestone, near the top of which the oil is found, and deeper down, salt water. The oil, when tapped by the drill, will rise 500 ft. or more in the hole. In some cases the water in the Niagara limestone has been badly injured by "wildcat" wells, which were improperly plugged or not plugged at all. Where the higher stratum has been cased off, the lower waters in time find their way into it by eating holes in the casing.

In constructing these wells, the casing is inserted through the drive-pipe and lowered to the bottom of the Niagara limestone, where it is driven solidly into the underlying shale, so as to prevent interference of the fresh limestone waters and the oil. Where a water-bearing cavity in the Niagara has been encountered, and the surface elevation is sufficiently low, there results a flowing well, the fresh water overflowing between the drive-pipe and the casing. Where the surface is too high, or the pressure absent or slight, the well will be non-flowing. In the latter case, the casings sometimes form an avenue through which oil-well wastes from the surface descend to the limestone and seriously pollute the fresh waters. Sometimes the oil waste accumulates in stagnant pools in the gravel overlying the bed-rock. Such instances, familiar also to the present writer, are described by Bowman in Water Supply Paper No. 113, U. S. Geological Survey, pages 45 and 46. As pumping on the water well increases, the oil and refuse floating on top of the water are brought lower and lower, until finally they are drawn into the pipe. This has been observed at Marion, Ind. Many of the city wells are high in chlorine, owing to salt water which has become mixed with the fresh waters. The fact that the pollution is sometimes experienced many hundred feet from any oil well indicates that the waters bearing the polluting materials have circulated through porous channels in the limestone.

Similar conditions to those in Indiana have been observed in the vicinity of Palatka, and elsewhere, in Florida, except that in that State the polluting materials are objectionable waters instead of oil wastes. In a number of places potable waters in upper water-bearing strata have become charged with mineral water from a much lower stratum, which has worked to the deterioration of the upper waters.

In Saginaw, Mich., the city water supply, from bored wells, as stated by Bowman in Water Supply Paper No. 160, U. S. Geological Survey, 1906, pages 94 and 95, was seriously injured by a number of salt wells which had been abandoned without proper plugging. At Dallas, Texas, the city water works draw their supply from the Woodbine and Paluxy beds. One well here penetrated the underlying Glen Rose beds and obtained mineral water under greater head, which rose and corroded the casing to such an extent that it entered and polluted the water in the upper beds. The waters were separated by inserting a packer between the Glen Rose and Paluxy beds and connecting with a casing to the surface.

Pollution of Water-Bearing Strata by Sewage Conducted Into Wells.

Another way in which waters of good wells have been seriously polluted is by the disposal of sewage through drilled wells in the vicinity. This method has been attempted in many limestone regions, always with the result that wells in the same formation were seriously endangered and sometimes injured. In 1903, Mr. S. W. McCallie made some experiments at Quitman, Ga., in view of determining the extent of pollution caused by this evil. (Water Supply Paper No. 110, U. S. Geological Survey, 1905, pages 45-54.) The authorities of the town wished to dispose of sewage by forcing it down drilled wells in limestone. The investigations of McCallie showed that such a proceeding would result in serious pollution of the entire underground water supply, and the project was abandoned.

Experiments were also tried in Florida by Dr. E. H. Sellards (Florida State Geological Survey, Bulletin No. 1, pages 64-66), and in Kentucky by Mr. George C. Matson. The usual procedure has been to insert salt into deep limestone borings, with the universal result that it was found, after a short time, by tests, to enter wells several thousand feet distant.

Nothing could be more disastrous to the purity of the underground water supply than the practice of using wells as sewers, and it is hoped the practice will be speedily abandoned.

Summary.

Such instances as those mentioned, in addition to other classes of evidence, bear testimony to the fact that all parts of a water-bearing bed bear a definite relation to all other parts of the same bed, and that in sinking wells, whether for water, oil, gas or other purposes, due respect should be paid to the conditions prevailing in the particular formation and to their effect on other wells in the vicinity.

A SMALL CAR SHORTAGE developed during the first half of October. The American Railway Association's Committee on Relations Between Railroads reports that on Oct. 13 there were shortages (chiefly in the East and South) totaling 23,431 cars. The surplus, or number of idle cars, was on that date only 35,977, a decrease of 17,411 in two weeks; this residue of idle cars was chiefly in the West and Northwest. The report shows the lowest surplus since November, 1907, and also the largest shortage since that period. In the two years intervening, the surplus reached a high point of about 420,000 at the end of April, 1908, and a low point of 111,000 at the end of October, 1908. The high record of 1909 was about 330,000, early in January.

Modern Progress in Mining and Metallurgy in the Western United States.*

By DAVID W. BRUNTON†, M. Am. Inst. M. E.

The wonderful advances in mechanics, chemistry, and electricity have all combined to aid the arts of mining and metallurgy to such an extent that progress during the last decade has undeniably been more rapid than ever before in the history of the profession. In all mining countries, improved transportation facilities, in many instances called into existence by the traffic created by the mines themselves, have done much to enlarge the field of operations by the reduction of freight, operating and living expenses, thereby bringing lower-grade properties into the producing class. Under normal conditions, as the age of a district increases, all these different factors should combine to offset the augmented cost attendant on deep mining, and greatly tend to prolong the profitable life of the mines.

The more recent and important improvements in our Western mining practice which have contributed most toward the advancement of the art may be briefly summarized as follows; but, before beginning this portion of my address, I wish to thank most heartily the many engineering friends who have so kindly furnished data covering their latest practice, without which this paper would have been even less complete than in its present form.

MINE MAPPING.—Not many years ago most mining companies thought it amply sufficient to have a surface-map of their properties and a composite map showing the different underground workings in their mines. To-day, almost every important concern maintains, in addition to the above, both stope and assay maps, while many of the larger companies add individual level, horizontal and vertical cross-section maps showing the underground geology in full. Upon these maps conventional designs in black ink are used to designate the various rocks, while the different veins or vein-systems are shown in colors. These sections are frequently drawn also upon glass sheets, which are then inserted in wooden frames provided with vertical or horizontal slots or grooves cut at the proper relative distances apart to correspond with any desired planes of cross-section or with the working levels of the mines in question. The great advantages of such plans and sections cannot be overestimated. They not only show at a glance the tonnage and value of the ore in sight, but also afford a guide for development work, whereas the old-fashioned maps were nothing but a record of the work performed, and were practically useless for any other purpose.

The improvement named has brought about another, the importance of which is just beginning to be recognized. I refer to the employment by large mining companies of economic geologists, who are not burdened with the duties of surveying, directing workmen, etc., but give their whole attention to the geological problems encountered in the work. The advice of such experts in the purchase of property, the running of exploration drifts, the location of shafts, etc., and the interpretation of local fault systems, and other structural features, has already proved of inestimable value to their employers.

SURFACE MINING.—Large ore bodies occurring near the surface can, in many cases, be most cheaply and satisfactorily mined by stripping off the overburden and loading the mineral into cars by either the "milling" or the steam-shovel system. In the West, steam-shovel mining is confined almost entirely to the low-grade copper deposits at Ely, Nev., and Bingham, Utah. The system employed follows closely that of many iron mines of Minnesota; and 95-ton shovels, with 3.5 cu. yd. (7-ton) dippers, are in common use. At Bingham, the Boston Consolidated Co. stripped the overburden from its deposit at the rate of 200,000 tons per month. The maximum amount handled in a calendar month was 282,903 tons, in August, 1907, and the maximum tonnage for a single day, with four shovels, is 15,000 tons. The Utah Copper Co. immediately adjoining this, is also carrying on equally extensive stripping and mining; and as many as 13 steam-shovels, and 26 locomotives have been counted at work within a radius of half a mile.

ROCK DRILLS.—The great improvements in core-drills, both diamond and calyx, enable us to-day to explore ground hundreds of feet in advance of the actual openings and afford great aid in all development work. Power drilling has now almost entirely replaced hand work, and a vast assortment of drills has been placed in the market, from which a careful engineer will often have extreme difficulty in selecting the machine best adapted for a particular service. Rock drills, reciprocating, air hammer, and electric air, are all in successful operation to-day; and with the steady improvement, both in design and material employed in construction, there is every reason to believe that the drill of the near future will be even more nearly perfect than those now in use.

*Presidential address at the Spokane meeting of the American Institute of Mining Engineers, September, 1909.

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MINE HOISTING.—Thirty years ago, while immense hoisting plants were in use on the Comstock, they were far from efficient, and were not copied even in miniature on smaller mines. The favorite plant in Colorado in the early days was called the Gilpin County hoist, and consisted of a rope-drum securely fastened at one end to a large wooden pulley connected by a slack belt to a stationary engine running continuously at a slow speed. When the signal was given to hoist, the operator opened the throttle of the single-cylinder engine, and brought the necessary working tension on the belt by means of a tightener operated by a hand lever. To-day, these primitive machines, large and small, have all been succeeded by direct or gear connected steam engines, equipped, whenever the tonnage is sufficient to justify the expense, with variable cut-off valve gear, post brakes and every modern improvement.

Steam hoists, capable of handling from 10 to 20 tons of total load, from depths of from 4,000 to 6,000 ft., at speeds varying from 4,000 to 5,000 ft. per minute, are now not at all uncommon. These immense plants are fitted with every imaginable device for increasing the efficiency, rapidity, and safety of operation, and the skill and artistic ability displayed in the design of some of the later Nordberg creations bring them to a point where they can almost be considered works of art.

In many places where water fit for use in boilers is scarce and electric current cheap, as at Cripple Creek, the electric hoist has almost completely replaced the steam hoist.

When large electric hoisting plants were first installed, it was found that the great amount of current necessary to start and accelerate the load brought a very objectionable "peak" on the transmission line. This difficulty has now been overcome by the Illgner and other similar systems, in which the energy stored in a large rapidly revolving flywheel cuts down, if it does not entirely prevent, the objectionable peak. Safety devices likewise have been very much improved; and a recent invention, whereby the cage tender is in constant signal-connection with the engineer, should do much to decrease the number of shaft accidents.

UNDERGROUND TRAMMING.—When mines were shallow, shafts numerous and hoisting facilities inadequate, hand tramming was almost universally employed, but with increase in depth came the necessity for better hoisting machinery and a reduction in the number of shafts, thereby increasing the distance over which ore had to be trammed. Then it was found that a high-priced man constituted a very expensive motive-power for pushing cars; horses and mules were put into commission; and, still later, air and electric locomotives have come into very general use. There has been much discussion concerning the relative merits of these two latter systems of underground haulage; but there is no doubt that each has its own field. Where the openings are dry and the roof sufficiently high and firm to carry the trolley-wire insulators, there is no question as to the desirability of using electricity, but where these conditions unfortunately do not obtain, the compressed-air locomotive is an excellent substitute.

TIMBERING.—Where the ore bodies do not exceed 10 or 12 ft. in thickness, and have a firm hanging wall, nothing can exceed the cheapness and simplicity of stulls; but when larger ore bodies are encountered and timbering is necessary, the system commonly employed is that of "square setting," invented by Deidesheimer and first used on the Ophir mine on the Comstock lode in 1861. Timber is yearly becoming more expensive, does not usually last well underground, and when the ore bodies are large, especially if there is a tendency to movement in the walls, "square sets" made from squere timbers are apt to "swing" and afford very little vertical support.

When large quantities of timber are required for square setting, in situations where the distance from the forest to the mine is not too great, round timbers are very much cheaper and more durable than square. A round log has about double the strength of a square timber cut from the inscribed square on its small end; and since, in the round log, the concentric rings of wood growth are unbroken and each protects the ring immediately underneath it from decay, the comparison, both in cost and in durability, is very unfavorable to square timbers. Automatic framing machines can now be had which utilize the full strength of round timbers by making a bevel joint outside of the square tenon necessary in all square-set timbering. This additional segmental contact area in the joints braces the round timbers so that they are much less liable to "swing" in large stopes than the square.

In some cases, "cut and slice" and "caving" methods are employed, in which the hanging wall is allowed to come down and rest on each successive floor as the ore is stoped out, and is prevented from mixing with the ore by a mass of crushed timbers and plank which follows down on the top of the receding ore. In the Utah Copper and Boston Consolidated mines, at Bingham, Utah, about 4,000 tons of copper ore are mined daily by the "caving" system. In some large mines the stopes are filled with waste as fast as they are freed from ore, and the ground above thereby prevented from caving, in the same way as if stulls or square setting were used. Steel and concrete are coming slowly into use in shafts, stations, and tunnels, and with the natural decrease in the price of iron and cement on the one hand and the rising cost of timber on the other, it is easy to see that the more durable forms of construction will eventually supersede wood on all permanent work.

The direct-replacement system employed in the Rio Tinto copper mines in Spain succeeded perfectly in holding both walls and surface in place on a vein from 200 to 260 ft. wide, and, by taking advantage of the wonderful skill of the Spanish miners in building dry stone walls, gives a new method of safely and economically mining the lower portions of the lodes which cannot be reached by the open-cast systems extensively in vogue there.

PUMPING.—In the United States, the old-fashioned Cornish pump, with its costly foundation, massive walking beam, huge plunger rods and ponderous balance bob, was supplanted many years ago by the direct-connected steam pump, which soon developed into a most efficient pumping machine with duplex, triple-expansion engines and every refinement possible in modern steam-engine practice. These have in many places been superseded by the electric-driven plunger pump, in which the high speed of the electric motor has been reduced by suitable train-gear. Latterly, quite a large number of electric pumps have been built in which the gear is entirely eliminated. The speed of the motor has been reduced, and that of the plunger raised, forming a combination known as the express pump. Pumps of this class, with capacities of 1,600 gals. per minute, raising water 1,550 ft., are now being very successfully employed in unwatering the Comstock Lode at Virginia City.

Within the last few years great improvements have been made in the electric-driven turbine pump, which, with its entire absence of valves and reciprocating parts, threatens to dominate the field completely.

Already we have single-stage turbine pumps, raising 35,000 gals. of water per minute 150 ft.; five-stage pumps raising 10,000 gals. per minute 600 ft.; six-stage pumps raising against 800 ft. head; and eight-stage pumps raising 400 gals. 1,400 ft.; and responsible firms are ready to contract to raise water by this system to any elevation up to 2,000 ft., and guarantee a pump efficiency of from 60 to 75%, according to conditions of service.

MINE LIGHTING AND SIGNALING.—Incandescent electric lighting has long since driven oil lamps and candles out of underground stations and permanent levels in which any large amount of work is carried on. The recently invented tungsten lamp with its high efficiency, giving 20 c.p. with an expenditure of only 25 watts per hour, makes it economically possible to extend electric lighting very greatly throughout underground workings. In some of the largest and most progressive mines, candles and oil lamps have already been replaced in the stopes by acetylene lamps, which are not only cleaner and safer, but give a much greater illumination for a given cost.

For mine signaling the flashlight system operated by interrupting, by means of well protected switches, the current passing through the station lamps, is rapidly replacing the old-fashioned cumbersome bell cord; and the latest moisture-proof mine telephones give instant communication throughout the underground workings, and to and from the surface, with little danger of interruption.

EXPLOSIVES.—The use of modern high explosives in mining and tunneling is now universal, but there is a crying demand for an explosive which can be more safely handled, and which on explosion or detonation will produce a smaller amount of noxious gases, which not only injure the health of the miners but delay the resumption of work after each round of shots has been fired.

Irregularities in the composition of explosives, variations in the strength of detonators, and differences in the speed of fuses are all fruitful sources of mine accidents, and, while too much "paternalism" is certainly to be avoided, it is doubtful if anything short of government regulation and inspection of explosives, detonators and fuses will ever bring about the uniformity necessary to safety.

MINE VENTILATION.—Less progress has taken place in this department than in almost any other, although the means for moving large quantities of air under slight pressures have been very much improved. The ventilation and cooling of metal mines have not yet received the attention which their importance demands. In this respect Western engineers could take profitable object-lessons from their brethren in the coal fields. Very few of our Western mine operators go to the trouble of recording temperatures and making ventilation maps, showing the direction of the air currents, etc., all of which data are necessary before a satisfactory system of either natural or artificial ventilation can be planned. As most of the Western mines are in hilly or mountainous situations, it is generally easy to provide two openings at greatly different elevations, so that the heating-effect of the workings can be dependend upon to control the direction of the air currents to such an extent as at least to cool and ventilate the workings partly. When these advantages cannot be obtained, centrifugal or forced-draft blowers, driven either by steam or by electricity, furnish an easy means of obtaining the desired results.

The latest high-speed electric direct-driven centrifugal compressors give pressures up to 45 oz., and have been built in sizes up to 40,000 cu. ft. of free air per minute; but there is apparently no limit to the size of the machines which can be built under this system.

TUNNELING.—As the United States continues to grow in wealth and importance, tunneling operations increase in like proportion, both in number and in magnitude. New York City and its environs are now underlain by a network of tunnels, and other cities are rapidly developing underground systems, since through the increase in population business and travel become congested. All over the United States, water-supply, hydro-electric power and the reduction of grades on railways are requiring new and expensive tunnels, to which, in the West, are added the great irrigation tunnels called for in both government and private enterprises. The result of all this activity in tunneling has been a vast improvement in both machinery and methods, and a greatly increased number of thoroughly trained and skilled workmen, so that records formerly unattainable in the United States are now being made in widely-separated localities. Table I. gives the monthly rates of progress reached by some of our latest achievements in tunnel-driving. The recent paper of Mr. Saunders* describes systems and results abroad, which show much higher rates of progress than we have yet been able to attain here.†

TABLE I.—PROGRESS IN DRIVING TUNNELS IN THE UNITED STATES.

Cowenhoven tunnel, Aspen, Colo., 7 by 8 ft.	May, 1893, 421 ft.
Roosevelt tunnel, Cripple Creek, Colo., 9 by 10 ft.	January, 1900, 435 ft.
Gunnison tunnel, Gunnison, Colo., 12 by 12 ft.	January, 1908, 449 ft.
Elizabeth tunnel, Los Angeles, Cal., 12 by 12 ft.	October, 1908, 466 ft.

GOLD DREDGING.—Chain-bucket dredging for gold was first attempted in 1867 in Otago, New Zealand, and the first steam-actuated dredge operating on this principle was built on the Molyneux in 1881.

From a few small dredges copied after those in use in New Zealand, gold dredging in this country has grown into a great industry, which is carried on successfully from the frozen gravels of the Arctic to the sun-scorched river bars of the tropics, and at all altitudes from 10,000 ft. down to sea level. Under stress of competition and the necessity of meeting new conditions, dredges have grown both in capacity and efficiency to a point not even dreamt of a few years ago. Dredges are now built with close-connected buckets, of capacities up to 13.5 cu. ft., and capable of handling 16,000 cu. yds. of gravel in 24 hours; some have been built with bucket-ladders capable of digging 67 ft. below the water line and 20 ft. above it. A new stacker now under construction will deliver tailings 160 ft. away from and 60 ft. above the deck of the boat. Improved construction and better management have rendered dredging operations less dependent upon weather; and last winter in Colorado a dredge was operated continuously at an altitude of 9,990 ft. where the temperature on several occasions fell to 20° below zero. The subject of suction-dredges has been fully considered in Mr. Granger's recent paper.‡

ELECTRIC TRANSMISSION.—No sketch of this kind would be complete without some notice of the immense service which the mining industry is receiving from long-distance electric transmission. While a few mines are favorably situated for the utilization of adjacent water power, many of the principal mining districts of the United States are at altitudes so great that any available water power is far below them. Again, as in the case of Nevada, Arizona and portions of Utah, the mines occur in an arid country where it is difficult to obtain sufficient water for domestic purposes, to say nothing of power.

Already the electric current is carried to all elevations from sea level to timber line, and there is scarcely a desert mining camp of sufficient size to justify the erection of a pole line that is not equipped with electric power. The ease with which this overcomes the old and apparently insurmountable problems of scarcity of water and fuel constitutes one of the delights of modern mining.

The use of electricity has also completely solved the old vexed problem of underground sinking and hoisting, so that these operations are now as readily carried on from deep tunnel levels as from the surface.

Transmission lines of all lengths up to 220 miles are in daily use, with carrying capacities ranging up to 40,000 KW. Long-distance transmission systems are in many cases operated at 100,000 volts, and new lines are

*"Bulletin" of the American Institute of Mining Engineers, April, 1909, pp. 337 to 364.

†Europe's best figures were recently surpassed at Red Rock tunnel, Los Angeles Aqueduct: 1,061.6 ft., sectional area 75 sq. ft., August, 1909. See Eng. News, Sept. 9, 1909, p. 281. But this was in soft shale, and the drilling was done by augers. Under similar conditions a figure exceeding 800 ft. was made in the Gunnison Tunnel. These records are not strictly comparable with hard-rock tunneling.—Ed.

‡"Bulletin" of the American Institute of Mining Engineers, April, 1909, pp. 389 to 410.

building to utilize even higher pressures. Recent improvements in insulation promise to make still higher voltages possible, which would mean a corresponding increase in the distance to which current could be profitably carried.

SAMPLING.—Few departments of mining engineering have shown greater advance than ore valuation.

In milling and concentrating plants, where fine crushing is a necessary preliminary, sampling is a comparatively easy and reasonably accurate operation, but where the ore is to be treated by blast-furnace smelting, crushing of any kind is objectionable and fine subdivision is prohibited. Forty years ago, for the valuation of coarse ore, "grab" sampling was in common use, and this method was replaced in slow succession by Cornish quartering, fractional division, and split-shovel sampling. Then came automatic sampling in many forms, but all taking a portion of the ore-stream continuously. In 1884 a new system of sampling was invented which automatically deflects the entire ore stream for a varying portion (usually one-fifth) of the time into the sample division. Numerous different machines working on this principle are now in use; and these types of sampling plants have been perfected to such a degree that, where the hopper ore cars which are now coming into general use are employed, ore may be unloaded, crushed, sampled, and reloaded into the outgoing cars, and the ground sample delivered in a locked steel box, without ever having been handled—the entire chain of operations being performed automatically.

CONCENTRATION.—The separation of valuable minerals from worthless gangue must have been one of the earliest operations in the history of metallurgy. Up to less than 100 years ago the pan, tub and inclined plane, which are all so graphically illustrated by Agricola, continued to be the only devices in use. Hand jigs were first introduced for the separation of coarser particles than could otherwise be handled, and the principles involved are in use to-day, although improved mechanical appliances have changed and enlarged operations to such an extent that the primitive origin would scarcely be recognized. About 35 years ago the use of air as a concentrating medium was successfully introduced, and, despite its many disadvantages, this system, assisted by numerous mechanical improvements, still exists and manages to hold its own where water is unobtainable or, for some reason, cannot be used. In skilful hands, some of the pneumatic separators give wonderful results, but the delicacy of the adjustments and the attendant dust will undoubtedly prevent any extensive employment of this method.

The pulsating water-current recently invented by a distinguished investigator in the concentrating field* has already won a place for itself in both sizing and jigging operations, and promises to become a most important factor in concentrating work.

Specific gravity is, however, no longer the only principle taken advantage of in mechanical ore sorting. To these have been added magnetic and static electric separation, and many different methods based on the surface tension of water (with or without the assistance of oil or acid), resiliency and affinity for grease. The latter method, used very sparingly in this country, finds its chief application in South Africa, where it is used in the separation of diamonds from other stones.

The recent discovery by Kunz and Baskerville that the use of ultra-violet light would enable an observer to determine by inspection, with reasonable accuracy, the percentage of willemite in concentration tailings, has already found commercial application on a very large scale, and opens up a wide field for speculation as to what the future may hold in store for us in this field.

The enormous size of some of the new concentrating plants erected in the West exemplifies in a marked degree the magnitude of the operations now being carried on. At Anaconda, Mont., the Amalgamated Copper Co. has an eight-unit concentrating plant, each section of which handles 1,000 tons in 24 hours; and some of the new plants at Ely, Nev., and Garfield, Utah, are but little smaller in size.

ROASTING FOR BLAST-FURNACE SMELTING.—The earliest roasting furnaces to prepare sulphide ores for blast-furnace smelting were small hand-operated reverberatories, with or without fusion hearths. These were followed by revolving cylinders and various types of mechanically operated reverberatory furnaces, all of which were not only expensive to operate and keep in repair, but yielded a product very badly adapted to blast-furnace work. To-day these old-fashioned furnaces, both hand and mechancial, have been almost entirely superseded by blast systems like the Huntington-Heberlein, Carmichael-Bradford, and Savelsberg, which make it possible to utilize the many advantages of blast-furnace smelting for the treatment of concentrates, fine ore and flue dust at very low preparatory costs. These systems marked a wonderful advance over the old reverberatory roast with its pulverulent product, but they were still open to the serious objection of requiring a large amount of manual labor in charging and discharging the pots and breaking up the sintered product. In spite of this drawback, the results obtained were so desirable that study and invention along these lines have been stimulated to such an extent that there are already in use mechanical roasting and sintering plants (system of Dwight and Lloyd), to which ore can be fed in a steady stream, and which will automatically deliver a desulphurized, sintered, and broken-up product in the best possible condition for blast-furnace work.

*Eng. News, Oct. 8, 1908, p. 385.—Ed.

LEAD SMELTING.—Progress in this department of metallurgy during the past decade, in the West, has been much hampered by three conditions: (1) all the lead-smelting plants operate almost entirely on custom ores, hence the supply is irregular in volume, grade and composition; (2) the great extension of the leasing system throughout the West tends to bring ore into the market in very small lots, thereby increasing the difficulties and cost of storage and bedding; (3) eight years ago nearly all of the principal lead-smelting plants in the United States passed into the hands of a corporation organized for that purpose and the industry was thereby deprived of the stimulus of healthy competition.

The largest lead furnaces in the United States have hearths 180 by 44 ins. and treat daily from 150 to 255 tons of ore, according to its character. Mechanical charging is used in some cases, but, while it slightly reduces operating costs, it is no improvement metallurgically.

In Australia, where different conditions prevail, the improvements in lead furnaces have kept pace with those in iron and copper smelting.

REVERBERATORY COPPER SMELTING.—In 1867, when Richard Pearce (afterwards President of the American Institute of Mining Engineers) built his first reverberatory furnaces at Black Hawk, Colo., they were considered the acme of metallurgical perfection and their successful operation did wonders for the mining industry of the State. The hearths of these furnaces were only 8 by 12 ft. in size, and their daily capacity was 12 tons. As the quantity of ore produced increased and the necessity for handling larger tonnages became apparent, the reverberatory furnaces have been steadily enlarged and improved, until to-day they have attained almost incredible dimensions, having a hearth area of 19 by 116 ft. and a daily working capacity of more than 300 tons, which, in the case of easily-smelted ores, has risen to over 400 tons. These large furnaces secure great saving of heat and uniform, continuous operation, for reasons into which I need not enter here.

BLAST-FURNACE COPPER SMELTING.—The early water-jacketed blast furnaces for smelting copper ore were small, round, wrought-iron affairs, about 30 ins. in diameter, and rarely smelted more than 12 tons of ore in 24 hrs. From this puny beginning, keeping pace with the rapidly growing copper industry of this country, furnaces have increased steadily in size and improved in mechanical construction, until they have reached the enormous dimensions of 87 ft. in length by 4 ft. 8 ins. in width, with a daily smelting capacity of 3,000 tons of charge. These furnaces are mechanically fed, work under an air-pressure of 40 oz. and give infinitely less trouble than their smaller progenitors.

The water jackets are completely sectionized, and it is possible to renew most of the sections without stopping the furnace. At first only one tier of jackets was used, then two tiers came into use, and now some of the most recent furnaces have air or water jackets replacing the brick superstructure, thus doing away with much of the roof-accretion nuisance. On furnaces built with a crucible, baby water jackets have replaced the old cast-iron plates, and water-jacketed nose pieces have greatly lengthened the life of the furnace discharge spouts.

The credit for the latest improvements in design and increase in size of both reverberatory and blast-furnaces is due principally to E. P. Mathewson, whose untiring energy as an investigator and skill as a metallurgist have made the Washoe plant, at Anaconda, the Mecca for progressive engineers from every country.

The recently invented acetylene blow-pipe promises to be of great service to blast-furnace engineers, as through its use it will soon be possible to obtain welded water jackets entirely free from the objectionable lap seams and rivets.

ELECTRICAL SMELTING.—A great amount of experimental work has lately been carried on by engineers in various parts of the world having for its object the utilization of the electric current in metallurgical operations, and there is no doubt that in the near future many minerals now smelted with fuel will be reduced to metals by electrical processes. The electric current possesses the great advantage of allowing a most efficient utilization of the heat and also complete control of the exposure of the molten metals to air or gases.

BRIQUETTING.—At many blast-furnace plants "fines" are made into briquettes with the ordinary die-and-plunger machines; but if free acid or copper sulphate be present, the surfaces of both dies and plungers are rapidly corroded, which obviously increases the diameter of the dies and diminishes that of the plungers. As this solvent action continues, a point is soon reached when the plunger no longer fills the die opening, and pressure forces the material through the space between them, instead of consolidating the mass.

When a sufficient amount of plastic material, such as slimes, can be obtained to mix with fine ore and flue dust, so as to give the mass the property of "flowage" under pressure, it may be briquetted in machines similar to those used in making building brick by the "stiff-tempered" process. Solvents do not interfere with the operation of these machines, and by constructing the working parts of steel and phosphor bronze, it is possible to make briquettes dry enough to pass directly into a blast furnace at the rate of 600 to 800 tons per day, for each machine employed, at a cost of less than half that of the die-and-plunger system.

CHLORINATION.—Chlorination is confined almost entirely to sulphide gold-ores carrying so little silver that its loss may be disregarded, and which require a preliminary roasting before treatment. The early methods of tank leaching have all been superseded by barrel-chlorination, and in some of the latest plants chlorine is produced by electrolysis instead of by the decomposition of bleaching powder with sulphuric acid.

The largest plants operating under this system treat custom ores, and the stress of competition, together with the necessity of handling constantly increasing tonnages, has brought about great improvements in both machinery and methods.

The most desirable features of this process of gold extraction are the high percentage recoverable and the rapidity with which clean-ups can be made, rendering it easy at all times to know exactly what results are being obtained.

The largest plants operating under this system are situated in Colorado City, Colo., where two mills owned by one concern have an aggregate capacity of 800 tons per day.

CYANIDATION.—While the first patent for extracting gold from its ores by cyanide solutions was issued in 1867, it was not until McArthur and Forest took it up in 1889 that practical results of any value were obtained. Since that time the use of the process has increased by leaps and bounds in all of the principal gold-producing countries, and to-day it is the principal factor in the world's steadily increasing gold production. Cyaniding seems to work with equal facility on raw ore, roasted ore, and tailings, and with the steady improvement in the mechanics as well as the chemistry of the process, it bids fair to do even greater things in the future than it has done in the past. Nor is its use confined entirely to the extraction of gold. In many districts it is operating with great success on mixed gold and silver ores. At Millers, Nev., two plants with an aggregate capacity of 700 tons per day are operating on Tonopah ores, in which the average ratio of silver to gold is 80 to 1.

The largest and perhaps the most complex cyanide plant in the United States is the Golden Cycle mill, at Colorado City, Colo., which has a daily capacity of 1,000 tons, and treats exclusively Cripple Creek ore, all of which requires careful roasting and very fine crushing. The Homestake cyanide mill handles a larger tonnage, but treats only tailings.

Next to this plant in point of size and importance, and handling ore of much higher grade, is the new mill of the Goldfield Consolidated Co., Nevada, which has a capacity of 600 tons per day, and contains the very latest improvements, culled from American, African, Australian and Mexican practice.

FUME RECOVERY.—No department of metallurgy has made slower progress than this most important division, but now, through an unholy alliance between the unscrupulous contingent-fee attorney and the greedy land owner, the success of "smoke farming" is compelling the smelting companies to do for self-preservation something which they should long ago have undertaken for profit. Out of the almost numberless devices which have been tried for fume recovery, the bag-house affords the best solution of the problem yet devised. Bags were used for the recovery of both zinc oxide and lampblack more than fifty years ago, but were not used for fume recovery until 1878, when Bartlett set up a small plant at Portland, Me. The first large successful installation of this kind was erected by the Globe Smelting Co., in 1885, and has been in continuous operation ever since. While the bag-house has been eminently successful in the recovery of blast-furnace fume, it cannot be used on fumes from reverberatory roasting or smelting furnaces, owing to the fact that a portion of the sulphur dioxide formed by the oxidation of the sulphur is raised to sulphur trioxide by contact with incandescent ferric oxide. At the United States Smelting Works, in Utah, provision for protecting the bag-house from sulphur trioxide is made by blowing into the flues zinc oxide, which immediately absorbs the sulphur trioxide present to such an extent that it has been found quite possible to use cotton bags. The bag-house has proved very efficient in recovering fume from lead refineries and all lead smelting operations excepting roasting.

In large copper-smelting plants, where large volumes of gas are produced carrying a sufficient amount of sulphur trioxide to destroy woven fabrics, three systems are in use—namely: radiation, decreased velocity, and friction—and in many cases two or more of these methods are combined. At the Washoe plant, in Anaconda, long steel-covered flues of enormous cross-section have been installed for a number of years, and, while this

system does not effect a complete recovery of the fumes, it is as nearly perfect as it is possible to make a plant to-day. At Great Falls, Mont., the Boston & Montana Co. is installing the friction system at a cost exceeding $1,000,000, which includes the construction of a stack 506 ft. high and 56 ft. in diameter and a dust chamber in the flue system, of such width that the furnace gases will pass through it at a velocity considerably less than 500 ft. per minute. From the roof of this flue chamber, more than a million steel wires will be suspended, an arrangement which experiment has shown to increase greatly the settling efficiency of the dust chamber. This installation is practically completed, but it will be some time before the results obtained can be accurately determined.

I need not add that where (as in some Eastern works) metallurgical and commercial conditions permit the manufacture of sulphuric acid from the fumes, this method offers special advantages.

Conclusion.

The subjects already alluded to occupy but a small portion of the field covered by our 4,000 widely scattered members, but I hope that enough have been mentioned to serve as topics for discussion at this meeting. The ever-widening range of operations, the constantly expanding magnitude of mining undertakings, and the continually increasing complexity of both machinery and methods are daily creating new openings for mining engineers. To meet this demand our technical schools and colleges are yearly sending out an increasing number of graduates, whose opportunities and responsibilities will be even greater than those of the engineers controlling the activities of to-day. Even now, one change very much to be desired is beginning to become apparent. Heretofore it has too often been considered that an engineer's accountability ended when he discharged his full duty to his employer. To-day we are beginning to realize that the public forms a third party, vitally concerned in the results of the work in which mining engineers are engaged. As large investments are usually held by divided ownership and stocks are often scattered far and wide, so that the owners of small holdings have little or no opportunity to become conversant with the exact conditions of the properties they represent, an engineer's first duty should be to see that no word or act of his can be construed so as to give one man an opportunity to take advantage of, or mislead, another. Every one, no matter what his station, has a duty to society and his fellow-men which can never be either ignored or neglected. The employer, whether an individual or a corporation, is entitled to all of the information and data which experience, diligent investigation, and careful study can bring to light, and while an engineer has a right to state probabilities from both indications and analogy, he should never assume the gift of prophecy and thereby delude both himself and others.

Specific information gained in examination or research for one client should never be utilized for the benefit of another, unless there is no possibility that such use will in any wise injuriously affect the interests of any previous employer. This restriction applies with full force to the dealings of the engineer himself, as he should always remember that information gained by him at the cost of another, no matter how laboriously it has been obtained, belongs to the party who paid for it. No matter what success, ability, industry, or chance may bring to an engineer, his career has been an absolute failure unless he can truthfully say in his heart of hearts: "No man is poorer because I am richer."

THE RECLAMATION OF ASIATIC TURKEY by irrigation and flood protection works, as studied by Sir William Willcocks, M. Inst. C. E. (Eng. News, July 4, 1907, p. 23), is still being seriously considered by the Turkish government. Under recent date Sir William has made a new report to the government in which he recommends a detailed treatment of four new projects, involving especially the Euphrates and Tigris rivers. These projects are estimated to cost about six million dollars, or about 1/5 of the entire reclamation scheme. The new Turkish government which, under the name of "The Young Turks," has recently come into power, looks favorably toward the projects but so far has not been able to raise enough money to warrant beginning the work. An appropriation of $600,000 for the coming year has been made but as this would require 10 years for the completion of the preliminary work and about 50 years for the whole project, it is thought that before long the government will let out the work on a concession basis, allowing the contractors the profits of the land for a certain term of years, in return for the execution of the contract.

This land is one of the earliest grain-growing countries in the world and has fallen into disuse wholly because of the decay of the ancient irrigation systems, the remnants of which are even now to be seen. It is estimated by Sir William Willcocks that a profit of from 15 to 20% can be easily made on the grain crops once the arid land is watered by his irrigation systems.

1,200-Volt Direct Current Car Equipment.*

By F. E. CASE.†

Direct current of 1,200 volts has been adopted in preference to 600 volts as the trolley potential of a number of interurban and other railways on account of lower first cost and lower cost of operation. That 1,200-volt current can be more economically delivered to the car requires little argument. On a railway having a given size and length of feeder a car equipped with 1,200-volt apparatus will entail a line loss of only one-quarter that of a 600-volt car of the same size operating at a similar speed.

With dense traffic, where cars are required to run on a very close headway, consequently giving practically a uniformly distributed load, the substations at 1,200 volts can be located twice the distance apart as at 600 volts for the same maximum per cent. line loss. Under the other extreme condition of two cars or trains only between substations, and passing midway, the substations can be located four times as far apart as at 600 volts with the same maximum per cent. line loss. The latter condition, however, is rarely practical for interurban operation on account of the great headway between cars. Under the usual prevailing conditions of interurban service it will be found that the substations at 1,200 volts can be located from 2½ to 3 times the distance apart as at 600 volts to give the same percentage line loss.

The adoption of commutating poles has made the operation of 1,200-volt generators entirely practicable. Where alternating current is better adapted to long-distance distribution, rotary converters in substations are also well designed to translate the alternating current to 1,200 volts direct. No more complicated or less reliable pieces of switchboard apparatus are required in the power-house or substation than for ordinary voltages.

Either the third rail or trolley wire can be used for carrying current to the car. One road is now successfully using the former and there are several others using the latter. The third rail is of the under-running type and is installed in a similar manner to a 600-volt practice, but the insulators are of somewhat increased dimensions. No radical departure from standard 600-volt practice is required in overhead line construction to ensure a safe insulation. Cross-suspension, side-bracket or catenary method of trolley-wire support can be used, but additional insulation over that used for 600 volts is, of course, required. The catenary form of suspension is usually recommended, as not only does it require a minimum number of poles and insulators, but it provides the most flexible support, which is a great advantage for high speed operation.

The standard trolley base, pole and wheel give better results than with 600 volts, as the current to be collected for a given weight and speed of car is only half, which increases the life of the wheel especially.

The motors are similar electrically to ordinary 600-volt commutating-pole motors, with increased insulation, and there is no departure in mechanical features from other direct-current motors for lower voltage. The brush holders are located in a similar manner and there are no more of them, so that inspection is just as readily made as in other direct-current motors. The commutation of the motors is so good that no more attention to the brushes and commutator is required than with low voltage motors of similar capacity. As the motors have the same electrical characteristics as other direct-current motors, the armature speeds are no greater and in consequence the bearings are equally long lived. Some motors have been furnished by the General Electric Co. for operating directly on 1,200 volts and others for use two in series. With the former it is possible to operate at only half speed on 600-volt portions of the line, but the latter motors can be connected in multiple so as to give the same speed on the low voltage as the high, which in many cases is a great advantage.

The car equipment consists of apparatus similar to that used for 600 volts, many of the parts being identical. Cylinder platform controllers have not been used in any instance, however, as they require the motor current to be carried above the floor and we have considered it advisable for obvious reasons to keep the apparatus that breaks the main circuit, under the car, where it can be suitably isolated.

Sprague-G. E. "Type M" control, comprising electrically-operated contactors, reverser and circuit breaker, is used. These parts are practically the same as for 600 volts with additional insulation where required. Both automatic and hand, or non-automatic, control have been furnished. The circuit connections are identical, for both the master control and the motors, to that used for 600 volts. Standard 600-volt contactors, operated

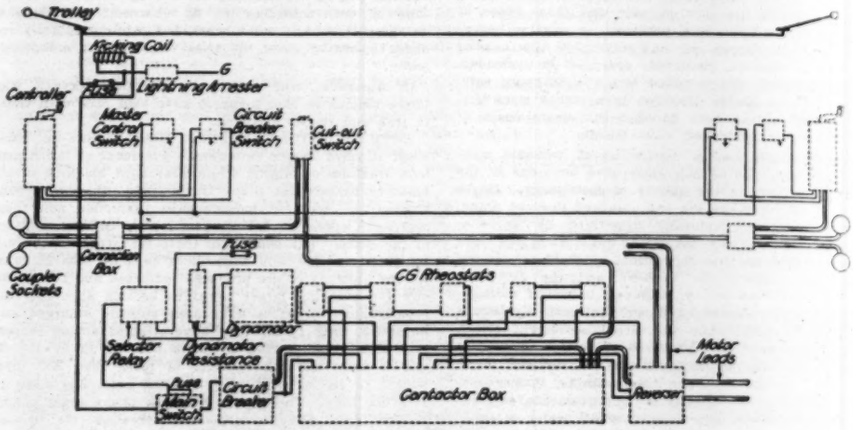

Fig. 1. Diagrammatic Arrangement of Apparatus.

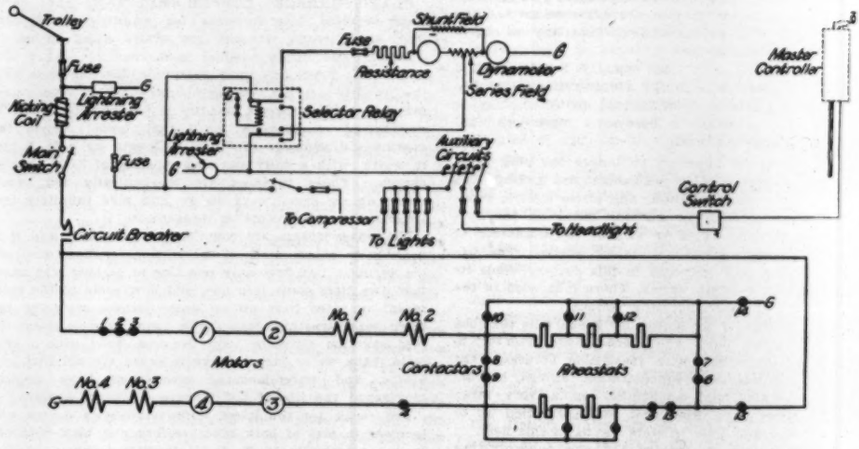

Fig. 2. Main and Auxiliary Electrical Circuits.

FIGS. 1 AND 2. DIRECT CURRENT, 1,200-VOLT STREET-RAILWAY CAR EQUIPMENT.

*Appendix to the report of the Committee on Equipment, presented at the annual meeting of the American Street and Interurban Railway Engineering Association, held at Denver, Colo., Oct. 4 to 8, 1909.

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by means of electro-magnets, are employed for making the power and resistance circuits in the contactor box, a few extra contactors being used to provide the necessary breaks in series to safely open the circuit. Practice has shown that a 1,200-volt current can be very satisfactorily interrupted by the contactors, and that the burning is not excessive. The contactors are thoroughly insulated from each other and from a supporting metal frame, this frame being in addition insulated from the metal contactor box. The interlock contacts of the control circuit are attached to the back of contactors as in recent 600-volt practice, but they are more highly insulated from them. Each set of these contacts is also completely isolated from its neighbor by insulating barriers.

Easily removable covers are provided on the front and rear of the contactor box so that the contactor burning tips and interlock contacts can be inspected readily. The contactor box is prepared for installation with iron conduit for both the main and control wires leading to the different pieces of apparatus, the same as for 600-volt equipments.

Proper insulation of the reverser contacts is easily secured, owing to the motor fields being reversed, instead of the armatures when the direction of car movement is to be changed, and also because the fields are connected to the ground side of the armatures. This connection of the motors has been adopted both in the new cylinder controllers and in "Type M" control for 600 volts. For commutating-pole motors, it is desirable, in order that the commutating-field winding, which is permanently connected to one side of the armature, may always be on the grounded side of the armature. The connection has also the advantage that fewer of the contacts have a high potential between them as the drop across the exciting field to be reversed is only about 15 volts.

When the armature leads were reversed on four-motor equipments, it was necessary to provide a complete break in the circuit at the midmovement of the reverser, as otherwise the contacts short circuiting the armatures, if the latter are rotating, would become burned due to the heavy current of low voltage generated under the influence of the residual field. This would occur on both two and four-motor equipments when the reverser was thrown from forward to reverse, and while the generating action was for a brief time only, the current broken was often sufficient to damage the contacts with a few operations. No such action occurs when the fields are reversed, however, and they can be short circuited by overlapping the contacts during the movement of the reverser without injury. This permits designing the reverser with a greatly reduced movement from forward to reverse position with a correspondingly increased range of low-voltage operation.

Incidentally, burning of the contacts on a four-motor reverser, when the latter was used for stopping a car by reversing, is now eliminated. On four-motor equipments the motors are permanently connected at the reverser in two groups of two each in multiple and the motors, as is well known, immediately begin to generate current as series generators when the reverser is thrown to its reverse position with the car in motion. Should the old reverser be returned to its forward position before the car is brought to rest, the heavy, high-voltage, generated current flowing will be broken at the reverser contacts, with the possibility of damaging them. With the new reverser, however, the fields are short-circuited at mid throw, which reduces the generating action of the motors, and instead of breaking the high voltage and heavy current of the armatures, only the small remaining voltage across the fields and a negligible current has to be broken.

A magnetic blow-out circuit breaker, located under the car, similar to the one generally furnished with "Type M" control, is used for an overload protective device. It is, however, provided with a more powerful magnetic blow-out and has an increased opening and insulation. The circuit breaker is set and tripped from the motorman's cab by means of an ordinary double-movement switch which connects to the proper train wires.

A magnetic blow-out copper-ribbon fuse box is provided as an additional protective feature for the main circuit. This is practically the standard box, using a fuse of the ordinary length, but extra coils provide an increased magnetic blow-out to take care of the higher-voltage arc.

Standard 600-volt cast-grid rheostats are used for providing the necessary resistance steps in starting the motors. These rheostats are effectually insulated from the angle irons to which they are attached by means of large collars and tubes surrounding the supporting bolts. The cast-iron grids are but half the width of those in the old rheostat, two being placed side by side. The convolutions of conductor are horizontal and but half the length of the old ones, which were vertical. This shape of grid can be supported with much less liability of breaking, or warping when overheated, than the old form, and the design is the result of investigating many different shapes. Four insulated rods are used for supporting the grids and also holding the end frames, the latter being made of sheet steel in order to reduce the weight to a minimum. The supporting bosses of the grids are slotted so that to replace a broken grid it is only necessary to loosen the nuts at the ends of the rods and slip out the parts of the damaged grid. This feature provides a ready means of replacing broken grids, or substituting ones of a different capacity when necessary, and will, therefore, form a great labor saver to the railway. The insulation on the rods is protected by short sections of thin metal tubing separated by insulating washers, and the operation of removing and replacing grids cannot injure it.

When a car equipped with four motors is required to operate at the same speed on both 600 and 1,200-volt sections, it is necessary to use a commutating switch for changing the connections of the motors. For 1,200-volt operation this switch connects the motors in two groups with the motors in each group in series, each group being handled as a single motor. In starting, therefore, the motors are all in series, and in the final position of the controller they are in a series-multiple, each motor being then subjected to 600 volts. For 600-volt operation, the commutating switch is moved to a position in which the motors in each group are placed in multiple, and in consequence when starting, the motors are in series multiple and in the final position they are all in multiple, each having 600 volts across it. In addition to connecting the motors in two different relations, the commutating switch changes the connections of the rheostats so that the proper values of resistance are obtained for the various steps. This commutating switch is arranged for operating either by hand or with air controlled by a valve located near the motorman. An interlock device is provided which prevents operation of the contactors if the motors are not properly connected for 1,200-volt running.

On some roads the operating conditions are such that only on the interurban sections is it desirable to obtain the maximum speed. To meet these requirements the commutating switch is, therefore, not necessary, and having 1,200 volts on the high-speed section and 600 volts on the city division gives relative speeds of about 2 to 1. Cut-out switches are used for removing a disabled motor and its mate from the circuit when necessary. In some instances this switch is placed in the reverser box and in others it is a separate device.

Current at 600 volts is used for operating the control and also for the car lighting. With the earlier equipments the air compressors are also operated at this voltage, but now current is obtained from a dynamotor, of waterproof design for mounting under the car. It consists of a single frame and set of field coils with an armature provided with two commutators and separate sets of windings connected in series across the line. A shunt field is connected across one-half of the armature, and it is, therefore, subjected to 600 volts. Up to this point the design of the dynamotor is little different from forms which have been used for several years. The new feature is a series field winding which is connected between the two halves of the armature and is provided with a tap at its center. In starting up, line current passes through the first half of armature, series field, and second half of armature to ground, thereby strengthening the normal field, and the machine operates as a compound motor. When, however, current is being taken from the tap in the center of the series winding for the control or lights, as shown on accompanying diagram, the two halves are opposing each other, and they consequently have no effect on the field strength. When the trolley leaves the wire with the dynamotor running, and the controller on, there is an immediate tendency of the dynamotor to deliver current to the motors, due to the momentum of the armature and the shunt field. The series winding now comes into play by demagnetising, or beating down, the field, since the direction of current has been reversed in the first half of the series field, and the two parts, therefore, no longer oppose each other. This action prevents an amount of current sufficient to blow the dynamotor fuse being taken by the motors.

On the 600-volt sections, current for the lights and operation of the control is taken directly from the trolley, and the dynamotor is shut down. On recent equipments the dynamotor is started up automatically, when the car runs on to a 1,200-volt section, by means of a selector relay. This relay has a single operating coil with plungers at both ends, so arranged that one of them will pull in at about 250 volts, and the other at 700 volts, these being the minimum operating voltages for the 600 and 1,200-volt sections, respectively. The light and control circuits are disconnected from both the trolley and dynamotor when the relay is not energized, the proper connections being made to correspond with the voltage applied.

To insure correct operation of this relay, a short, grounded section of trolley wire is interposed between the 1,200 and 600-volt portions of the overhead line. When the car runs to this from the 1,200-volt section, the dynamotor is, of course, short circuited, but, due to the action of its series coils, no great amount of current can be taken from it in this direction. This brief short circuit removes all potential from the selector-relay operating coil, and the plungers, therefore, return to the open-circuit position of the contacts. As the car reaches the 600-volt section the relay again establishes the proper connections for the lights and control.

The air compressors on some recent equipments are wound for operating at 1,200 volts, as there is no difficulty in obtaining good commutation and insulation for this voltage. When the car is running on the 600-volt section the compressor will, of course, be required to operate for a longer period if air is used to the same extent as on the 1,200-volt portion, but this is easily taken care of in selecting the proper capacity of compressor.

Present and Prospective Commerce of the Mississippi River from St. Louis to the Gulf of Mexico.*

[Compiled under direction of the Board of Examination and Survey of the Mississippi River.]

The Mississippi River, including its tributaries, drains about half the United States, and it has a total of about 16,000 miles of river (Census Bureau reports) susceptible of navigation. As every one knows, it is not many years since this river was noted for its large steamboat commerce, very large in proportion to the commerce of the entire country; and it, in fact, was the great highway for not only freights but passengers passing into and through the Middle West. For many years, however, its water commerce has been steadily diminishing, while the inland water commerce of the entire country has been as rapidly increasing, so that to-day its water supremacy is gone; and such condition of affairs is well known not only to the Mississippi Valley but to the United States public in general, who are wondering why the river is not more utilized and how it can be made more useful.

But it is also well known to the engineering public of the country that the present river conditions of the Mississippi Valley are many times better than in the days of its greatest commerce; the river from St. Paul to deep water above New Orleans having now a navigable depth of nearly twice as great everywhere as in former days, and its obstruction by snags and wrecks being at present so slight as to be rarely mentioned. The marked diminution of water commerce, under such circumstances, cannot be due to questions of navigation and river engineering, and must be due to other conditions, such as those of demand and supply, water and rail competition, and of business management in general.

This situation on the Mississippi River (and its tributaries) is not the only similar case in the United States. Even Chicago, Ill., in spite of its size, its increasing population and factories, its direct frontage on deep water of the Great Lakes, and its excellent inner harbor (Chicago River) of the olden type, has recently found itself in the same predicament and has been obliged to make special search for the reasons thereof.

There are six different points of inquiry to be specially investigated in any serious examination of the present and prospective commerce of any waterway, viz., (a) the extent of population and of manufacturing, agricultural, and other business interests which call for water transportation; (b) the waterway itself, with its navigable channels, and especially their condition and capacity; (c) the boats, including their equipment and service; (d) the amount and character of the freights either actually carried or demanding carriage; (e) the ports of other terminal points of load and discharge, including their harbors, piers, wharves, slips, docks, unloading and loading machinery, and other transfer facilities; and (f) the rail and water competition and their relative capacities, facilities, service and freight rates. These will be taken up briefly in the above order.

Population and Business Interests.

The Mississippi River Valley for miles back on each side of the river between St. Louis and the Gulf is mainly an alluvial valley, richly endowed by Nature, and susceptible of rapid, extensive and valuable future development, which is at present delayed mainly by lack of population and funds.

Tables of area, population, and railroad mile-

*Condensed from Appendix No. 20 to the Report of a Board of Engineers on the Project for a 14-ft. Deep Waterway from the Lakes to the Gulf. See Engineering News, June 24, 1909 for a full reprint of the report itself. The complete report with all appendices is printed as Document No. 50, House of Representatives, 61st Congress, 1st Session.

age of counties and states along the Mississippi River between St. Louis and the Gulf and of the busy countries of Europe bring out forcibly the contrast between this part of the world and Europe.

The United States is very much better off than Europe in the amount of land and length of railroads per head of population. Other sources of information give approximate estimates for 1900 of about 4,000 miles of waterways in Austria, 1,400 in Belgium, 7,500 in France, and 8,000 in Germany. This information, all taken together, indicates approximately five miles of railway, three-fourths of a mile of waterway, and 11,000 population per 100 square miles of country in Europe, against six miles of railway, two-thirds of a mile of waterway, and 2,600 population per 100 square miles in the entire United States. The seven states adjoining the lower Mississippi River have about four times as many miles length of railway per head of population as Germany, although only two-thirds as many per square mile, and about seven times as many miles length of navigated waterways per head of population as Germany, although only about the same number of miles length per square mile.

No very large amount of local commerce can be expected when the population is as low as 86 to 24 per square mile, including cities, and where, in a total length of about 1,265 miles, there are only seven towns or cities of above 10,000 population or only 23 of above 5,000 population each. There is, however, an excellent opportunity for future growth, which must necessarily come in due time. As the population increases in this rich alluvial valley of the lower Mississippi, so will the agricultural and manufacturing industries increase; and the lower valley will have a surplus of products to distribute to the upper valleys or to foreign countries.

The Waterway and Its Channels.

As regards the navigable waterway itself, between the Gulf and the Great Lakes, it has been possible for several years, even during low-water seasons, to freely send boats of 25 to 30 ft. draft from the Gulf 270 miles to New Orleans, Baton Rouge, and Bayou Sara; 9 ft. draft thence 840 miles to Cairo, 8 ft. draft thence 182 miles to St. Louis, thence 4½ ft. draft 365 miles up the Mississippi and Illinois rivers and through the Illinois State Canal to Chicago.

Connected to this through route are good boat channels of at least 4½ ft. at low water (7 ft. during 1907-8) from the mouth of the Illinois River 620 miles up the Mississippi to St. Paul; and of at least 2½ ft. at low water from just above St. Louis 2,285 miles up the Missouri to Fort Benton (with 3½ ft. below Sioux City and 4 ft. below Kansas City); and of 9 ft. at mean stages of water from Cairo about 1,000 mies up the Ohio to Pittsburg (under improvement to 9 ft. depths at low water), and thence with 5 ft. low-water depth 128 miles up the Monongahela to the Pennsylvania coal fields; and 6 ft. at low water for 90 miles up the Kanawha to the West Virginia coal fields, besides long distances at mean and high water stages up all the many other less important tributaries, among which are the Allegheny, Little Kanawha, Muskingum, Kentucky, Cumberland, Tennessee, St. Croix, Minnesota, Osage, Gasconade, St. Francis, Yazoo, Arkansas, Red, all of which carry good depths at mean stages of water and penetrate regions of great fertility and great natural resources, though as yet sparsely settled and largely undeveloped.

This waterway system of about 14,000 miles length of navigated rivers, so far as concerns its existing boat channels, their depth and capacity for boat travel, *is, as a whole, the equal of anything in Europe* [italics ours.—Ed.], where much of the canal and upriver boat traffic is done on 3 ft. draft; most of it is done on 6 to 8 ft. draft, and where as much as 10 ft. draft is exceptional. All the rivers of the Mississippi Valley, so far improved, are in far better navigable condition at the present time than before improvement work was started.

As to the upper Mississippi River, the last annual reports of the Chief of Engineers and the officer in charge show the river to be far better in every way to-day than formerly, and show also that there is no difficulty whatever in securing for the entire length of river at least 6 ft. depth at times of dead low water, with reasonable rapidity, as soon as the cost of the same shall be provided by the Federal Government. During the fiscal year 1907-8 (see annual reports for 1908) there was not at any time at any point of the river from St. Paul to the mouth of the Missouri (except in the Des Moines Rapids Canal) a channel depth of less than 7 ft.

On the Missouri River the work laid down by the Engineer Corps in past years contemplated and prophesied a good channel wherever and whenever provided for by the necessary funds. In this case the work was started at a point between St. Louis and Kansas City and carried on downstream with the idea that the funds would be regularly forthcoming until the work was completed, such arrangement being best suited to quickness and economy of work. But as the appropriations were not continued long enough, the improvement never reached St. Louis. However, in the last annual report (1908) of the Chief of Engineers, including the report of the officer in charge of the Kansas City office of the Missouri River improvement, it is shown that over the completed stretch of river, including 45 miles of the worst parts of the old river, a depth of at least 6 ft. at low water has been secured and is still maintained, the construction works are still doing excellent service, much valuable new land has been reclaimed, and much valuable old land has been protected from future destruction. The whole river will be made equally good as soon as funds are forthcoming. Meanwhile 4 ft. draft can be carried up to Kansas City, 3½ ft. to Sioux City, and 2 ft. to Fort Benton every day of the year except when the river is closed by ice.

On the Mississippi River from St. Louis to Cairo the increase in depth and width of channel during past years, while under the improvement by the Engineer Corps, has been quite marked, and to-day there are only a few days at a time for a few times each year when a boat drawing 8 ft. cannot freely go up and down the river anywhere between St. Louis and Cairo. Such improvement affords conveniences and facilities to navigation far in advance of anything at present being utilized or being demanded by the boating interests, and such improvement is practically equal to that which the Ohio Valley interests are at present demanding for their own river, and with which they will be well satisfied. The delays of navigation on this stretch of river from St. Louis to Cairo are trifles in comparison to the winter delays of navigation on the Great Lakes, where the boat commerce is many times greater and where all reasonable demands of commerce are to-day fully met and satisfied.

On the Mississippi River below Cairo the river is also in far better condition now than ever before, and except for a few days a few times each year there has been maintained for several years a least depth of 9 ft., capable of carrying all boats that may reach it from the Ohio River after the improvements in progress thereon shall have been completed.

As a matter of fact, there are very few rivers anywhere in the United States or Europe that are to-day in better condition for navigation than the Missouri, the Mississippi, and the Ohio, taken as an entire system. Moreover, so far as their improvement has been carried out under the Engineer Department methods, the results obtained per dollar of cost have equaled anything in foreign countries, the main trouble to-day being that the improvement is only partial, having been carried on of course only so fast as the Federal Government furnished funds for the work.

The past decrease of commerce and the present lack of increase of commerce on these rivers is not due to lack of depth in the river so much as due to the conflicting interests of land and water transportation, and to the laws governing the movement of raw products toward the centers of manufacture, and of manufactured products toward the centers of consumption, combined, perhaps, with a lack of development in steamboat construction and driving power.

The small extent of water transportation over the waterways of the United States in the Mississippi Valley, and its marked decadence in recent years, has been a matter of great surprise to many American engineers, as well to the engineers of Europe. The mileage of navigable waterways of the Mississippi basin, including its canals and the depth and width of the navigable channels therein, is great, even in comparison with those of the inland waterways of Europe; and the river facilities, so far as the navigable channel is concerned, were good years ago, and as above shown have been very much improved and increased in recent years. In special cases, such as lumber on the upper Mississippi and coal on the Ohio, the individual load carried by or towed by single boats on the Mississippi is larger than in Europe. But the length of river haul is long per unit of population served; except at New Orleans, the dockage facilities are very slight, sometimes nothing more than a sloping bank, and are always expensive; and except at New Orleans the terminal facilities, including arrangements for transfer to rail connections, are almost entirely lacking. Freight rates by water are therefore high in the Mississippi Valley as compared with the rates by rail between the same terminals.

In Germany and the adjacent European countries, with their dense population, with a less waterway mileage, and only about one-quarter the railway mileage per head of population that there is in the Mississippi Valley, and with high railroad rates, it is comparatively easy for them to keep their waterways full of steamers and barges, distributing to the interior of the country quantities of freight far in excess of anything that can be expected in the United States for many years.

The main feature of difference between the Mississippi Valley system and those of European

TABLE I.—VESSELS AND CAPACITY OF THE LOWER MISSISSIPPI RIVER FROM ST. LOUIS TO NEW ORLEANS FOR 1906 AS SPECIALLY REPORTED IN 1908 BY THE DEPARTMENT OF COMMERCE AND LABOR (CENSUS BUREAU).

	Vessels		Proportion of entire Mississippi system.	
	Number.	Gross tonnage (tons).	Number, per cent.	Tons, per cent.
Commercial vessels:				
Tugs and towboats..	131	10,004	21	16
Packet boats	90	17,474	23	32
Barges and tows....	354	94,213	4	2
Ferryboats	52	14,496	33	65
Yachts	37	858	17	26
All others	8	437	21	20
Grand total	672	137,482	7	3

TABLE II.—NUMBER OF BOATS OF DIFFERENT TONNAGE CAPACITIES, MISSISSIPPI RIVER, 1906, AS REPORTED IN 1908 BY DEPARTMENT OF COMMERCE AND LABOR (CENSUS BUREAU).
(Omitting ferryboats, yachts, and small pleasure boats.)

By system and class.	Size of boat by tonnage: 5 to 49 tons.	50 to 99 tons.	100 to 199 tons.	200 to 299 tons.	300 to 399 tons.	400 to 499 tons.	500 to 999 tons.	1,000 to 2,500 tons.	Total all sizes.
Lower Mississippi system:									
Freight and passenger packets.....	30	21	7	10	4	5	12	1	90
Tugs and towing vessels.....	68	39	14	6	1	...	3	...	131
Barges and tows.....	28	63	90	52	36	31	43	11	354
Ohio River system:									
Freight and passenger packets.....	70	29	26	19	9	3	9	2	167
Tugs and towing vessels.....	168	87	81	20	15	7	20	1	399
Barges and tows.....	367	180	1,582	651	29	371	1,988	2,227	7,404
Upper Mississippi system:									
Freight and passenger packets.....	80	22	14	8	1	2	62	...	133
Tugs and towing vessels.....	55	24	7	3	...	...	...	...	89
Barges and tows.....	200	165	57	5	1	1	...	...	429
Whole Mississippi system:									
Freight and passenger packets.....	180	72	47	37	14	10	27	3	390
Tugs and towing vessels.....	291	150	102	29	16	7	23	1	619
Barges and tows.....	595	417	1,729	708	66	403	2,031	2,238	8,187

TABLE III.—VALUE OF FREIGHT-CARRYING VESSELS OF UNITED STATES IN 1906, AS REPORTED IN 1908 BY DEPARTMENT OF COMMERCE AND LABOR (CENSUS BUREAU).

By class.	Atlantic and Gulf, tons.	Pacific, including Alaska, tons.	Great Lakes and St. Lawrence, tons.	Mississippi, including tributaries, tons.	All other inland waters, tons.
Average tonnage per vessel:					
Steam (self propelled)	269	486	1,143	102	64
Unrigged (barges and tows)	200	192	270	521	133
Average value per ton:					
Steam	$133	$117	$61	$90	$103
Unrigged	18	30	32	2	10
Average value per vessel:					
Steam	35,826	56,698	69,799	9,196	6,634
Unrigged	4,789	5,776	8,540	1,179	1,310

rivers at the present time is that in the Mississippi Valley (the Ohio River excepted) there is a lack of freight demanding transportation at rates high enough to justify the establishment and operation of good boat service, that the paralleling railroads with gentle grades stand prepared to carry all the freights more directly, more quickly, and more cheaply than steamboats can do even in wide and deep channels such as those between New Orleans and Baton Rouge, and that local conditions and laws favor the railroad service rather than the boat service in matters of transportation. As population and general business increase, as the railroad service becomes congested, and as the boat service improves in its methods of handling freight and of collecting goods from the shipper and delivering them to the consignee, the waterways will probably again resume their proper place as a valuable and economical method of freight transportation, at least for the heavier and bulkier classes of goods.

The Boats with Their Equipment and Service.

The Department of Commerce and Labor, Census Bureau, special report on transportation in 1906 is especially full and complete in the matter of boat description. A few only of its tables are here inserted. For the benefit of persons not accustomed to the daily use of such tables the following explanations may be found useful: Vessel tonnages must not be confused with cargoes or freights, as the tonnage refers usually only to the measured capacity of the vessel, remains the same whether the vessel be loaded or empty, and is usually reported only once a year, while the cargo or freight is an actual load reported each time that the vessel is loaded or unloaded. Moreover, the registered tonnage of a vessel may often differ by 10 to 25% from the tonnage of its full cargo, according to the methods of measurement and loading and to the character of the cargo. River or port commerce or traffic usually means the total of shipments and receipts, which is nearly double that of either alone. Even within the limits of a closed district the shipments and receipts may not agree in amount, owing sometimes to the consumption of the cargo by the vessel or its passengers, sometimes to a credit of some of the freights to other districts, and sometimes to incompleteness of reports.

In descriptions of vessels of the Mississippi system the Department of Commerce and Labor makes St. Louis the dividing point between the upper and lower Mississippi systems, crediting the upper system with whatever it sends to or by or receives from St. Louis, and crediting the lower system in similar fashion, but giving all the local business within its harbor to the lower Mississippi. In its division between rivers of these systems credit is given to a river only when the movement starts or stops within the river, and not to a movement which both starts and stops beyond the limits of the river, so that grain freight from points on the Missouri to points on the Tennessee, or coal freight from the Monongahela to the lower Mississippi, would be credited to these rivers and not to the Ohio through which it passes on its way. This is done to avoid a confusing duplication. The 1889 reports in some cases represent a somewhat different distribution, so that comparisons of 1889 and 1906 reports are subject to minor discrepancies. Where reports are based upon combinations of reports of various departments there are also sometimes slight differences due to the fact that the census reports cover calendar years and all boats of five tons or more measurement, while the navigation reports cover fiscal years and only documented boats. In all the census reports the federal vessels have been omitted, as also all boats of less than five tons burden. The group of vessels termed "unrigged" by the Census Bureau includes barges, flatboats, lighters, scows, dredges, derricks, pile drivers, hoisting barges, floating elevators, canal boats, and all similar craft, when without means of self-propulsion. The unrigged craft alone or in tows, handled by a small towboat, perform for the river the same functions as are performed by drays and express wagons on land, and are increasing in large numbers every year.

The table of vessels and capacities of the lower Mississippi shows that while the lower river carries two-thirds of the ferry service of the entire Mississippi system it handles only about one-third of the packet-boat freights and only about one-fiftieth of the barge freights, except where it receives these barges from the Ohio River or from the upper Mississippi.

While the Mississippi Valley waterways have, since 1889, actually gained in total number of vessels, value of vessels, and gross income, they have relatively fallen far behind in every way in the general advance by the freight-boat service of the entire country in tonnage, value, income, etc.

The table giving number of boats of different tonnage capacities in the Mississippi River shows that on the lower Mississippi the majority of the boats are of less than 200 tons capacity, although barges and towboats are broadly distributed among all sizes up to 2,000 tons. This is in decided contrast with the upper Mississippi River, where the majority of boats are less than 100 tons, and in equally great contrast with the Ohio River, where more than one-half of the barges are over 500 tons. This table, taken in connection with the preceding table, shows very plainly that the mass of the freight in the Mississippi Valley is being carried on barges of comparatively light draft rather than in packet boats.

The table giving the value of freight-carrying vessels in the different parts of the United States brings out forcibly the much greater cost of vessels per ton of freight carried along the ocean frontages than on the inland rivers. The greatest contrast between the cost of the barge or tow and the self-propelling vessel per ton of freight carried is in the Mississippi Valley, where the self-propelling vessel shows a first cost per ton 45 times that of the barge.

The Ohio system includes nearly two-thirds of all towboats and a little more than three-fourths of all towboat tonnage of the Mississippi Valley. The lower Mississippi is prominent in ownership of ferryboat tonnage, and the upper Mississippi in the ownership of yachts and pleasure craft.

A little over two-thirds of all the barges and tows in the Mississippi Valley, constituting nearly four-fifths of the total tonnage, belong to ten owners, all of the Ohio system, i. e., large coal companies of the Pittsburg district. The barge equipment of these ten owners handled over 40% of all the barge freight, even including all harbor work and car ferries.

The old wooden coal barges, which could be used but once and then sold for rough lumber on their arrival at the lower river ports, are gradually being abandoned in favor of steel barges, which, besides being stronger than the wooden barges, will carry about 20% more cargo on the same draft of water.

The flat-bottom stern-wheeler still holds its preeminence as the prevailing and most useful type of steamboat on the Mississippi. Side-wheelers, where used, are employed mainly for packet service, and especially ferry service, and the center-wheelers almost exclusively for ferry service. Screw-propeller boats, while forming nearly 25% of the total number, carry only about 6% of the total tonnage. Gasoline boats amounted in 1906 to nearly 40% of the total number, but their tonnage was only about 4% of the totals and their horsepower about 4% also. A large amount of the river business is being captured by these small gasoline boats, which for light work are replacing the more expensive steamboats. This accounts for the large increase in number of new vessels showing a decrease in average tonnage.

On the lower Mississippi and Ohio rivers, as on European improved rivers and canals, the tendency is to seek economy of freight transportation by towed barges rather than by self-propelling packet boats. Wherever the traffic is offered in lots of over 200 to 1,000 tons the use of towboats and barges becomes the most economical.

Three and a half million tons of coal or heavy freights can be sent from Pittsburg to New Orleans by use of 9-ft. draft steel barges and stern-wheel towboats in large fleets at a cost not exceeding $7,000,000 for plant and $2,700,000 for annual operation or about 0.03736 cents per ton-mile (Ohio River Board report).

One stern-wheel towboat has been known to handle as much as 56,000 tons of freight in one tow (Ohio River Board report), a freightage equal to that of five of the largest lake vessels or three of the largest ocean steamers, or of 8 to 15 miles length of railroad cars; and to handle as much as 2,000 ft. of logs, enough to fill 14 trains of 24 cars each by rail (Ex-Governor Van Zant, of Minnesota, 1904 Dubuque Convention).

On the 1,200 or more miles of Belgian waterways around Antwerp the barge traffic of about 7,500,000 tons is mostly carried on shallow-draft barges of less than 1,200 tons each (Montreal Harbor Commission report).

On the 7,500 or more miles of German waterways connected with Hamburg the barge traffic of about 8,500,000 tons is handled by about 1,400 self-propellers and about 5,000 barges of from 100 to 1,500 tons of from 3 to 6 ft. draft (Montreal and Chicago Harbor Commission reports).

On the Rhine, where the traffic is over 16,000,000 tons, much of the traffic is carried by barges (towed tandem in groups of two to five) of about 460 ft. length, 47 ft. breadth, and carrying about 3,500 tons when fully loaded to about 10 ft. draft, the channel depths varying from 6 to 10 ft. (Chicago Harbor Commission report), as well as by

TABLE IV.—RECEIPTS AND SHIPMENTS AT THE PORT OF ST. LOUIS, CALENDAR YEAR 1907.

		Receipts and shipments, in tons.				
	Number of passengers.	Grain and its products.	Cotton.	Cotton seed and its products.	Live stock.	Coal and coke.	Lumber.
Lower Mississippi River	42,167	10,576	1,522	260	10,673	166,360	25,101
Upper Mississippi River	50,735	9,218	.....	...	7,018	.....	4,084
Missouri River	6,776	2,928	.....	...	346	.....	132
Illinois River	5,925	2,194	44	...	6,510	.....	811
Total	*105,603	24,916	1,566	260	24,547	166,360	30,128

	Receipts and shipments, in tons.					
	Logs.	Iron, steel and metals.	Groceries and provisions.	Oil.	Unclassified and miscellaneous.	Total tonnage.
Lower Mississippi River	39,375	739	4,355	87	50,740	300,788
Upper Mississippi River	1,500	269	4,899	..	16,460	43,443
Missouri River	.....	98	329	..	2,241	6,104
Illinois River	.....	85	1,640	..	5,229	16,513
Total	40,875	1,191	11,253	87	74,670	375,853

*The Steamboat-Inspection Service reports 464,250 passengers carried in local excursion traffic.

NOTE.—This table was compiled from reports of the Merchants' Exchange of St. Louis and from records in the office of the secretary of the Mississippi River Commission.

smaller barges of 1,000 tons each (Ohio River Board report).

On the Volga, with traffic of over 14,000,000 tons, of which three-fourths is upstream, economical rates of as low as one-half mill per ton-mile are reached during good water by tows of barges of 11 to 12 ft. draft (Ohio River Board report). But the controlling depth on crossings of the lower 1,300 miles was reported in 1908 as only 5¼ ft.

No vessels of over 2,500 tons make use of the Mississippi Valley except in the deep-water portion of the river below the mouth of Red River. Although every deep-draft boat reaching New Orleans could easily proceed up the river about 130 miles further, to Baton Rouge, there is apparently no incentive for its doing so, as the goods can best be put ashore at New Orleans, where the terminal facilities are good, after which railroad charges for delivery at factory sidings are usually less than river freights combined with drayage up the bank and across the city or country to the factory.

The daily expense of large steamers is so great that they must avoid all possible delays in loading and unloading in order to be profitable. For example, on the Great Lakes, where modern efficient transportation methods are aready in use, a steamer, the "E. J. Earling," has been fully loaded with 9,277 tons of ore in 70 minutes, averaging 7,288 tons per hour, and the "George W. Perkins" has been fully unloaded of 10,346 tons in four hours and ten minutes, averaging 2,582 tons per hour (Census Bureau Report, 1906). The keynote of cheap transportation service on the Great Lakes is not simply large boats, but is preeminently the reduction to a minimum of all delays at terminals as well as en route.

The Great Lakes have been often referred to as an illustration of the enormous development of freights by reason of the existence of deep draft and as an argument for deep drafts in rivers. The experience of the Great Lakes navigation development is, however, not properly applicable to that of waterways in the other parts of the United States, as the Great Lakes, for the greater part of their distance, have broad, deep channels, more like the ocean than like any rivers of North America except the lower St. Lawrence. The movement of deep-draft boats in broad, open channels cannot be properly quoted as an illustration of what would happen to similar boats in narrow, winding, river channels.

Large, deep-draft, heavily loaded boats are unwieldy, especially when trying to back against the current; and when coming downstream such boats cannot be handled safely except in wide, deep channels, such as are far greater than can ever be expected in the Mississippi River above the mouth of Red River. While an ocean steamer might safely go slowly up the Mississippi against the current with a draft somewhat less than the channel depth over its bars, it is very doubtful whether it could ever get down the river with safety except during high freshets when all bars were deeply submerged.

In order to put the Mississippi River Valley waterways, as regards facilities of transportation, on a par with the railroad systems of the valley, which have branches or sidetracks to every city or town within easy reach, it would be necessary that the box cars of railroads should be represented on the river by barges of uniform draft for the entire river system, so that one or more barges could be loaded at factories and freighted along the river in large tows, to be later collected at depots at the mouth of each tributary, where new tows could be assembled for through towage to their final destination, each barge, at the end of its route, delivering an unbroken cargo to the consumer. Such condition is practically achieved in Europe by the great number of its light-draft barges and the great number of small harbors or havens scattered along its rivers and canals.

Amount and Character of Freights Carried and Demanding Carriage by Water Routes.

Letters were sent out in the fall of 1907 to commercial organizations and individuals supposed to be specially interested or specially well posted as to river valley commerce at all the large cities from the mouth of the Illinois River to New Orleans, asking information as to the existing local shipments and receipts by rail, and especially those which might have been taken care of by boats if a 14-ft. draft in the river had been available continuously during the preceding year. Later, in 1908 and the early part of 1909, further letters were sent out to secure additional information and especially to find out what definite information existed among the commercial organizations of the valley as to the relation between boat and rail rates along the river valley. The replies were considerably fewer and less full than expected.

These tables show very clearly the comparatively small amount of tonnage carried by the Mississippi River between St. Louis and New Orleans; especially small if omitting the coal which comes out of the Ohio River on barges of light draft.

Starting at St. Louis and proceeding downstream, it will be seen that the average annual traffic from St. Louis to Cairo by water is only about 80,000 tons, of mixed character. At Cairo, about 1,240,000 tons of coal come into the river, of which about 1,070,000 tons go downstream, about 200,000 tons being dropped off at Memphis and about 120,000 tons more being dropped off at various points in small quantities between Cairo and New Orleans, leaving about 750,000 tons delivered at New Orleans.

At various points along the river below Memphis and Vicksburg small quantities of coal come aboard from local mines or storehouses for use either on local steamboats or distribution to local landings in the neighborhood of the points of shipment. Between Cairo and Memphis about 170,000 tons of logs and lumber are picked up by the boats for delivery, mainly at Memphis. Below Memphis, about 900,000 tons of sand and gravel and about 220,000 tons of logs and lumber are taken on board for delivery, mainly at points between Memphis and Vicksburg. Below Vicksburg, about 190,000 tons of logs and lumber, 150,000 tons of sand and gravel, 100,000 tons of oil, and 60,000 tons of cotton and cotton seed are taken up at various points for delivery, mainly at New Orleans.

Outside of the above the freight is insignificant. The average through freight from Cairo to New Orleans is less than 900,000 tons of coal, and less than 400,000 tons of all other freights.

The return freights between New Orleans and St. Louis by water comprise about 100,000 tons of oil taken on at New Orleans and delivered between there and Vicksburg, about 50,000 tons of cotton and cotton seed taken on above New Orleans and delivered between there and Vicksburg. Above Vicksburg, about 160,000 tons of logs, 140,000 tons of lumber, and about 40,000 tons of cotton and cotton seed are taken on board for delivery, mainly at points between Memphis and Cairo, inclusive. Above Memphis, about 200,000 tons of logs and about 160,000 tons of lumber come aboard for delivery, mainly at Cairo, although about 40,000 tons of logs and 30,000 tons of lumber go through to St. Louis. At Cairo, out of the coal received from the Ohio River, about 170,000 tons go upstream to St. Louis. The average upstream travel from New Orleans to St. Louis is only about 300,000 tons, mainly lumber, logs, and coal.

The passenger travel, both downstream and upstream, is small, except locally between Memphis and Vicksburg, where it amounts to about 60,000 either way.

The coal, logs, lumber, sand, and gravel are all most advantageously carried on light-draft barges, such as those at present used on the Ohio River. Once that this material has been loaded on the barge moving downstream the cost of transportation will be much less per mile by barge than it will by heavy-draft packet boat, if the cost of the upstream travel of the boat to receive the goods be taken into account.

There are no longer any through passenger or packet boats from St. Louis to New Orleans. All through freights (except on barges) must usually be transferred from packet to packet at Memphis and Vicksburg. In the same way passenger or packet boats from New Orleans rarely go up the Mississippi above Vicksburg, where freight must be transferred. Occasionally a few passenger boats make the through trip upstream or down for the benefit of excursionists, as at Mardi Gras, but only a few times per year.

The tables of freight shipments for the entire Mississippi River system showing a comparison from 1889 to 1908 (Table V.), while bringing out very plainly the great and almost uniform loss in boat commerce since 1889 (the only gain being that of the Yazoo River), shows that the least loss has been in the Ohio River system, where the low-water depths are the least, and where only from one-fourth to one-half of the year is available for boats of 8 to 9 ft. draft. At the same time it shows that while on the tributaries a large proportion of the freights are carried by packet boats, the lower Mississippi carries over two-thirds and the Ohio River carries as much as 92% of its freights in barges and tows.

The grain traffic of the Mississippi River has for several years decreased very heavily, having lost about 78% since 1889; the decrease on the upper Mississippi being about 60% and that on the lower Mississippi about 96%. The latter decrease is due to the fact that the cost of the boat transportation from St. Louis to New Orleans, added to the extra cost of ocean transportation from New Orleans to Europe, is to-day (1907-8) greater than the rail charges from St. Louis to New York, plus ocean carriage New York to Europe.

Coal, sand, stone, etc., constituted in 1906 about 87% of all barge freight, being about 86% on the upper Mississippi, 92% on the Ohio, and

TABLE V.—FREIGHT SHIPMENTS, MISSISSIPPI RIVER SYSTEM, FOR 1889 AND 1906.
[Arranged by rivers, as reported in 1908 by Department of Commerce and Labor.]

	1906. Self-propellers. Tons.	Per ct.	1906. Barges and tows. Tons.	Per ct.	1906. Total, tons.	1889. Total, tons.	Change since 1889. Gain, Per ct.	Loss, Per ct.
Upper Mississippi	153,932	25.8	441,953	74.2	595,885	3,947,364	..	85
Illinois River	32,764	31.0	73,062	69.0	105,826	180,264	..	41
Missouri River	84,790	8.2	952,269	91.8	1,037,059	2,132,820	..	51
Other tributaries above St. Louis	1,876	9.7	17,455	90.3	19,331		..	99
Total upper river system	273,362	15.5	1,484,739	84.5	1,758,101	6,260,448	..	72
Ohio River system	1,246,437	8.2	13,980,368	91.8	15,226,805	15,796,968	..	3
Lower Mississippi system	835,587	32.8	1,710,600	67.2	2,546,187	6,232,087	..	59
Total Mississippi system	2,355,386	12.1	17,175,707	87.9	19,531,093	28,289,503	..	31
Total upper and lower systems	1,108,949	25.6	3,195,339	74.4	4,304,288	12,492,535	..	65
Details of system, Lower Mississippi River:								
Arkansas	23,175	92 7	1,819	7.3	24,994	1,662,717	..	85
Ouachita and Black, La.	18,125	72.1	7,011	27.9	25,136	93,707	..	73
Red	14,147	98.1	270	1.9	14,417	100,145	..	86
White	25,433	57.9	18,500	42.1	43,933	86,393	..	49
Yazoo	52,751	48.7	55,606	51.3	108,357	77,380	39	..
Black, Ark.	23	.1	20,036	99.9	20,059		..	..
Lower Mississippi proper	693,516	32.0	1,475,065	68.0	2,168,581	4,206,745	..	45
Other tributaries below Cairo	8,417	6.0	132,293	94.0	140,710			

TABLE VI.—STATEMENT SHOWING THE AMOUNT OF FREIGHT, IN TONS, RECEIVED AND SHIPPED AT ST. LOUIS BY EACH RAILROAD AND RIVER, FOR THREE YEARS.

	Received 1908.	1907.	1906.	Shipped 1908.	1907.	1906
Total in tons	23,871,102	29,445,669	27,620,287	18,772,888	18,374,916	17,861,191
Total by rail	23,577,922	29,156,094	27,292,617	15,700,158	18,296,416	17,772,006
Total by river	293,180	289,575	327,670	72,740	78,500	89,185

47% on the lower Mississippi. Next to coal, the chief commodity is sand in short hauls, often entirely within a single harbor.

Ports and Terminals for Water Traffic.

The Montreal Harbor Commission report makes a useful distinction between the words "port," "harbor," and "dock;" using the term "harbor" to mean a place of shelter for shipping, the term "dock" to mean an interior basin, and the term "port" to mean not only the collection of piers, slips, wharves, docks, harbors, roadsteads, entrance channels, but also the terminal accommodations and equipments by which freights are exchanged between boats and land conveyances.

Using a somewhat similar set of definitions the Chicago Harbor Commission unites with the Montreal Harbor Commission in bringing out forcibly the fact that water frontage alone does not make a port, and harbors and docks alone do not make a great port; but that the supremacy of a port depends mainly upon its ability to exchange land and water commerce easily, readily and economically.

The Mississippi River from St. Louis to the Gulf has at present only one real port, New Orleans; and that one is so far but partially developed and most of its developments are limited to the interchange of ocean freights with steam railroads and common roads, without much attention to interchange with inland boats.

So far as channel approaches and water frontages are concerned, Baton Rouge is as well provided as Manchester, England, or Antwerp, or Hamburg; but the latter cities have each recently spent amounts varying from $25,000,000 to $100,000,000 to provide themselves with the terminal facilities, useful wharves, docks, piers, slips, unloading and loading machinery, warehouses, railway sidings, railway storage, etc., necessary to transform them from harbors to ports.

St. Louis, Mo., has little wharfage either public or private except the graded river bank; East St. Louis has almost no public landings and few private ones; Cairo, Ill., has several piers and slips and some few floating boat landings and warehouses, but all under private monopoly. Memphis and Vicksburg have limited public landings consisting merely of graded banks and occasional floating warehouses. The other cities are less well provided. Such transfer facilities as exist at the Lake Superior and Lake Erie grain, ore and coal harbors are unknown on the Mississippi. The injury to freights and cost of transfer by reason of necessary rehandling at the water's edge and subsequent cartage up the bank and across the city to the consignee are usually sufficient to outbalance a decided higher freight rate by rail.

The only people in the Mississippi Valley who have paid much attention to terminal facilities for freights are the railroads; and consequently they command the transportation business. Individual boats and small corporations cannot afford to pay for such terminal facilities and the cities and towns have either not yet seriously considered the question of establishment of such facilities or are not prepared to pay for them.

Even on the Great Lakes, the railroads so dominate this situation that (Chicago Harbor Commission report) for the past many years only one out of many steamboats lines has been able to stand alone without being under the control of railroad terminals; and it is the water rates which are now being gradually raised to equal the rail rates, instead of the rail rates being lowered to or controlled by the water rates.

The harbor commissioners of Montreal in their report of 1908, of comparative study of modern port development in Europe, have the following suggestions to make as regards the best development of commerce and harbors:

> The success of passenger and mail service depends upon the existence of costly ships, fast trains, first-class hotel accommodations at the terminals, direct route from business center to center, and harbors of sure and easy approach.
>
> Freight service and the handling of freight cargoes requires freight-handling devices that will handle freight in the least possible time, large storage areas for the collection of freight as near as possible to the ship's side, and direct railway or inland waterway connection to the centers of production and consumption.
>
> The ideal harbor for both passengers, mails, and freights will be one that attracts a paying business by its comfort, regularity, safety, as regards passenger service, and by its regularity of cargoes, efficient port management and equipment, and good locality as regards freights. These requirements mean the necessity of good channel approaches and of large-tonnage vessels, with rapid transfer appliances for mail.

According to foreign experience and present practice, every city should be required, or at least urged and encouraged, to provide extensive free landings and good connections from the same to the center of the business part of the city easy for passengers and freight. The General Government can well afford to contribute much to the improvement of river fronts past good free landings and docks, because of the general development resulting from the establishment of good harbors at large commercial cities; but foreign practice indicates that the General Government should discourage the establishment of docks by private owners on governmentally improved streams except where there already exist free landings sufficient for ordinary service of all boats and where, at the same time, the private docks shall furnish improved facilities fully worth their dock charges, and that especial care should be urged upon all states and municipalities to see that rights of way given to railroads shall not unnecessarily prevent the later establishment of boat landings or prevent the free use of existing and future landings or their easy and free connection with the business portion of the adjoining communities, and that where such facilities are not provided the river-front improvement should be assessed upon the dock owners or left undone in favor of other places where such requirements have been fulfilled.

Rail and Water Competition.

The Chicago and Montreal Harbor Commission reports show plainly that one of the main reasons for the great use of inland waterways abroad is their better terminal facilities and their higher railway freight rates, combined with the denser population and the greater need of transportation. Although the water rates abroad are less than the rail rates, *the foreign water rate is often higher than the United States rail rates.*

By strict attention to business and by improving their terminal facilities and their collecting and distributing arrangements, the railroads can to-day make profits at rates which are no longer profitable to steamboats. A comparison of rail rates and water rates from New Orleans to up-river points above Baton Rouge, and of rail rates and water rates from St. Louis to down-river points below Cairo will make this point quite evident. Until terminal facilities at the water's edge are much improved there is little to be gained by any increase of draft in the river greater than necessary to float barges of the draft found most economical in the Ohio and in Europe.

Railroad development in the United States, and especially in the Mississippi River basin, has been so enormous as to have attracted the attention of all foreign engineers. In the United States single trains often carry loads five times as great as in Europe. The habits of the United States public demand more freights and longer hauls per unit of population than in Europe. The large areas of comparatively level country in the southern Mississippi Valley, the northern Ohio Valley, and the great plains east of the Rocky Mountains have made possible in the United States long hauls and heavily loaded trains over gentle grades, resulting in low costs, impossible in Europe, and approaching even in the United States in some cases very closely to the cost of water transportation. The railroad freight of the United States in the last 20 years has nearly tripled in consequence.

Waterways as routes for transportation possess over railways certain decided advantages, as follows: Foremost in importance is the fact that the United States waterways are public highways; open to every boat irrespective of its ownership; second, their channels are usually so wide that boats can always freely pass each other, and each boat is usually independent of all others as to use of both channel and landings; third, landings can usually be made and passengers and freight discharged at any point along the route at the will of the boat agents; fourth, the use of the waterway and landing places is usually either free from tolls or charge for cost of construction and maintenance, or else the charge is slight. Other advantages exist, but they are of minor importance. In proportion as any of these conditions are restricted by nature or by monopoly or by tariff charges the advantages of water transportation diminish very promptly.

On the other hand, waterways as routes for transportation in comparison with railways have disadvantages, as follows:

They are rarely straight, and so are usually much longer than corresponding rail routes, almost always one and one-half times as long and often three times. They are subject to special delays by weather conditions, as by fogs liable to occur at any time of day or night for uncertain and very variable intervals and by low water, freshets, and ice formations, occurring less often but lasting longer at a time. They naturally occupy the lowest levels of large areas, so that necessarily all freights after being unloaded must be hauled uphill in order to reach a place of actual use or sale. Good natural wharves and landings are few; good artificial wharves or landings are too expensive for construction by small communities, and cost of rehandling from shipper to boat and from boat to consignee is usually large. Boat service being easy of installation and comparatively free of monopoly and control is not easily organized under large companies; through shipments are not easily arranged and guaranteed between distant points. Repeated rehandling by irresponsible persons often becomes necessary, and damage to through freights is not easily prevented nor its responsibility easily determined nor its cost easily adjusted. In proportion as these conditions are intensified the final cost of transportation increases and the freight charge must be increased or the boat must go out of business. These disadvantages may often be so great as to determine the shipper to send the goods by rail even when the ton-per-mile freight charge by water is considerably less.

While boats can afford to carry bulky and heavy goods at much lower rates per ton-mile than do railways, the difference may easily be more than counterbalanced by the damage to lumber and furniture and frail materials by careless or repeated rehandling and also by the cost of haulage between the boat and the places of business of the shipper and consumer. Again, the rehandling to and from cars is almost always done under cover from rain and sun, while the rehandling to and from boats is usually done in the open.

Furthermore, it must be remembered that in many cases of shipment by rail the shipper himself places the goods inside the car on a siding at his own factory or warehouse and the consignee unpacks the same in the same way, and not only does the rail freight charge cover the entire cost of delivery from shipper to consignee, but the lesser amount of handling by rail diminishes both the risk of damage and the insurance charges. For a proper comparison of the final cost of shipment by the two routes the boat and rail rates must both be increased by the cost of movement at both ends of the route between the terminals and warehouses. A similar increase must be made in any proper comparison of time delays in shipment by the two routes. These conditions alone are sufficient to explain why the lumber yards of Chicago and many other large cities are losing their lake and river business, even though located at the water's edge, and also why most of the Mississippi boat traffic is at present restricted to local business, which cannot be easily or economically reached by railroad sidings, and also why the Mississippi River is so little used over its 130 miles between New Orleans and Baton Rouge, where there has existed from time immemorial at all hours of the day and every day of the year a clear channel of several hundred feet width and about 30 ft. depth.

Municipal Legislative Reference Libraries.*

By SAMUEL H. RANCK†.

As a result of the brilliant work of Dr. McCarthy, at Madison, Wis., "legislative reference library" has come to be a fascinating term to librarians and many others; and consequently the idea so splendidly developed in Wisconsin has been adopted by a number of states. More recently the same idea has been extended to municipalities. Such libraries have been organized in Baltimore (1907), Newark, N. J. (1907), Chicago (1908), Milwaukee (1908), and I believe in one or more other cities.

In Baltimore the library is in the City Hall, directly across the corridor from the quarters of the City Library, but with which it has no connection.

In Chicago the Municipal Library was added to the Bureau of Statistics, and is located in the temporary quarters of the City Hall. When the building operations now in progress are completed on the new City Hall it will be moved into that building.

In Milwaukee the quarters for the Municipal Reference Library are on the 8th floor of the City Hall. The ordinance establishing this department provides that the librarian be appointed by the mayor, subject to confirmation by the Common Council.

In Newark municipal reference work is performed by the Bureau of Statistical Information, under the direction of the city clerk. Its establishment was an outgrowth of the discussion, at the meeting of the League of American Municipalities in 1907, of the best means of informing city officials on all matters affecting the administration of municipal affairs. Besides the mass of local municipal records, dating from the settlement of Newark as a town, in 1666, there are about 8,000 volumes of municipal reports of other cities available for the work of the bureau.

By resolution of the Common Council in November, 1905, the Public Library of Grand Rapids was made the medium of exchange for all municipal publications, and on this basis the library has been gradually building up a very considerable collection of municipal documents, both local publications and those of other cities. In addition to these documents it has long been purchasing numerous books and pamphlets, dealing with municipal questions.

At this point let me call attention to the fact that the centralized handling of municipal publications in our American cities is something that is the exception rather than the rule. Relatively few cities have one official from whom one may secure all the annual reports of the different departments of that city, not to mention the other publications. It seems to me, therefore, that the first essential for building up municipal legislative reference libraries in a number of cities is the centralization of the handling, distribution, exchange, etc., of all publications of each city with all other cities; and of course wherever there is a municipal reference library, this library should be the central bureau for that city.

To what extent should cities endeavor to collect these publications from other cities? In the first place, I feel very strongly that it is nothing less than useless and a waste of time and money for most of our small cities, with their present resources, to endeavor to build up an extensive collection of municipal documents of this kind, for few of our cities are in a position to undertake the handling of such a collection satisfactorily. To gather a lot of municipal reports, ordinances, charters, etc., from a hundred or more cities is of little or no value unless the collection is classified, cataloged and indexed so that the matter desired is readily available; for be it known that there are municipal publications and reports which are more uninteresting—sometimes unintelligent—and which are arranged in such a way that it is exceedingly difficult to extract anything of value from them, the reports emitting, if anything, darkness rather than light. To attempt to gather material of this sort and keep it in an unorganized way is worse than useless. Most cities would give up such libraries in disgust after a few years' effort, and with most librarians municipal publications would be in as great disrepute as were the public documents of our national government some years ago.

The point of this whole matter is simply this: if the municipal legislative reference library, which is necessarily based largely on municipal documents and reports giving first hand information, is to be of service, it must be well organized and up to date, all of which means a considerable expenditure of time, space and money, and under trained and skillful management. The present financial resources of most of our public libraries will not permit of the handling of a collection of this kind in the way that is necessary to make it the means of great efficiency in the city's government.

If, however, the city should decide to have this sort of work done for it and for its officials, should the public library do it or should a separate organization be created for this purpose? I feel no hesitancy in saying that, except perhaps for our very largest cities, and except perhaps in places where local conditions are peculiar, the public library is so organized that a department of this kind could be created and administered to the satisfaction of all cheaper and better than by the creation of a separate independent organization or department.

The Charter Revision Committee of the city of New York has been requested by a committee of the Merchants' Association of that city, of which Prof. Edwin R. A. Seligman, of Columbia University, was the chairman, to incorporate a provision in the new charter for that metropolitan city for the establishment of a municipal library along the lines discussed in this paper, the same to be a branch and under the management of the New York Public Library. If the New York Public Library could do this work for New York there is every reason to believe that the public library *could* do this work in any city, unless temporary local conditions prevented.

By making the municipal legislative reference library a department of the public library it would encourage the study of municipal questions on the part of citizens generally much more than by running it separately.

When legislative reference work is made a department of the public library the city must adequately support it financially, so that efficient and aggressive work can be done at short notice. Furthermore, the work must be placed definitely in the hands of one person, and in our larger cities it would require frequently, if not constantly, one or more assistants. It should be the business and duty of the head of this department to know personally the officials of the city government, members of the council, the mayor, heads of the different departments, etc., etc. The mere collecting of books, pamphlets, papers, etc., and the expression in print or by letter alone of a willingness to aid any or all persons will not bring about the desired results in the way of intelligent use. It goes without saying, also, that the librarian is always absolutely honest and impartial in all this work. He must not look upon this work as that of a reform bureau, or a publicity bureau, but rather as an impartial agency for furnishing knowledge and light.

As these municipal reference departments are organized at present each city is necessarily duplicating an immense amount of work done in the other cities. The number of questionaires that are being sent broadcast over the land, a considerable number of which duplicate each other, is getting to be a burden that sometimes becomes a nuisance. Sooner or later it will be absolutely necessary to systematize this work in some way for the whole country, so that what is done for one city is done for all cities. Whether such a central bureau will be established by the Federal government along the line of the work that is now being done by the Census Bureau, or whether it will be undertaken by a private or voluntary organization remains to be seen.

The idea of a central bureau is by no means a visionary one. Germany is pointing the way. On April 1, 1906, the German Städtetag opened such a bureau in Berlin, where with its library as its source it "furnishes information to its members, to smaller municipalities, to local boards, and to private persons." The German Städtetag is a voluntary organization or cities somewhat similar to the League of American Municipalities.

Prof. E. A. Ross, of the University of Wisconsin, is of the opinion that somewhere in the central west there should be organized and established a central bureau for the municipalities of America to which cities or individuals could go or send for information. Much of the information sought for could be secured as quickly, and usually more fully, more satisfactorily and cheaper, from a central bureau of this kind than it could be collected and digested by the city doing the work itself.

*From a paper read at the Bretton Woods Conference, American Library Association, June 29, 1909.

†Librarian of the Grand Rapids (Mich.) Public Library.

Results of Meter Installation in the Water System of Cleveland.

The general introduction of water meters in Cleveland, Ohio, begun in 1902, has brought about striking results. Besides greatly reducing water consumption and waste and materially cutting down pumping expenses, the meters have made possible a postponement of the enlargement of mains and pumping equipment, as set forth in the annual report of the water-works division of the Cleveland board of public service for the year ending Dec. 31, 1908.

For the 20 years preceding 1902, the number of meters in use increased gradually with the increase of the total number of connections, but the percentage of the metered connections remained fairly constant in the neighborhood of 6%. In 1902, the metered services were increased to about 20% of the total number of connections. Since that time, the number of meters has been rapidly and steadily increased, as shown in the accompanying table, until in 1908, the per cent. of the total number of connections metered was 93.6%.

The effect of meters on per capita consumption is shown in the last two columns of the table. The daily consumption per inhabitant increased by irregular increments from 45.4 gals. in 1874 to a maximum of 169.4 gals. in 1901, an average gain of about 4.6 gals. per year. This gain was largely due to the increasing proportion of the population supplied with water. Since 1899, however, practically the entire population has been supplied, so the consumption per inhabitant is a true index of the rate of consumption. The high rate attained at the time when the general introduction of meters was begun is perhaps to be attributed to the increasing use of water for industrial purposes.

In 1902 the influence of the seven or eight thousand meters installed appears to have had but little more than balanced the factors tending to increase the per capita consumption, but in 1903 there was a substantial reduction, and as a larger proportion of the connections were each year supplied with meters the rate of consumption was rapidly brought down to 100.3 gals. per inhabitant per day, the figure for 1908. The average daily pumpage declined from 69,964,742 gals. in 1902 to 52,049,504 gals. in 1908, although the number of connections in use was increased in the same period from 56,816 to 74,490.

It is estimated that, at the rate of increase prior to 1902, the total pumpage for 1908 would have been 44,587,904,482 gals. The actual pumpage was 19,050,118,331 gals. The saving in pumpage costs on the difference of 25,537,786,151 gals. amounted, at $6 per 1,000,000 gals., to $153,227. Deducting the total cost of operation and repair of the meter department, or $92,351 from this figure, leaves a net saving of $60,876. Furthermore, had the pumpage increased to the estimated figure, it would have necessitated the extension of the West Side Tunnel, and additions to the pumping stations and mains at a total estimated cost of $2,500,000. The amount spent in the purchase and setting of ⅝-in. and ¾-in. meters from 1900 to 1908, was $1,100,000, and the interest and depreciation charges on the difference of $1,400,000 may be added to the saving effected by meters.

From the consumer's standpoint, the saving may be computed by comparing the amount of the meter receipts from domestic consumers, which were $360,368, with the $640,403, which would have been the total charge under the assessment rates, a saving to domestic consumers of $280,035.

Mr. Edward W. Bemis is Superintendent of the Cleveland Water-Works and shares with the Board of Public Service and Mayor Tom Johnson the credit of this remarkable achievement in municipal administration.

TABLE SHOWING THE EFFECT OF METERING WATER ON THE PER CAPITA CONSUMPTION; CLEVELAND, OHIO.

Years.	Total meters in use.	Per cent. of connections in use metered.	Gallons used per day— Each inhabitant.	Each consumer.
1874.....	73	1.28	45.4	141.1
1880.....	444	4.43	65.3	145.2
1885.....	1,175	6.38	93.5	139.3
1890.....	1,794	5.80	106.1	128.6
1895.....	2,228	4.99	136.6	151.1
1899.....	2,810	5.37	153.3	168.6
1900.....	3,140	5.87	168.9	172.9
1901.....	3,540	6.42	169.4	174.1
1902.....	11,296	19.88	167.8	.....
1903.....	25,193	42.81	141.6	.....
1904.....	30,370	50.09	138.5	.....
1905.....	44,706	69.70	130.8	.....
1906.....	56,712	82.04	123.0	.....
1907.....	63,993	88.60	117.5	.....
1908.....	69,733	93.61	100.3	101.0

THE OUTPUT OF NATURAL ASPHALT, related bitumens and bituminous rock that entered the market from quarries and mines in the United States in 1908, together with refined asphalt produced from the crude material, was 185,382 short tons, according to a bulletin of the U. S. Geological Survey. This output was valued at $1,888,881. This shows a decrease from the output of 1907, which amounted to 223,861 tons valued at $2,826,489. The imports in 1908, mainly from the island of Trinidad, were 151,674 tons with a value of $624,979. Exports in 1908 showed an increase of about 20% over those of 1907 and had a value of $451,968.

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A remarkable typhoid-fever record is being made this year at Richmond, Va., as compared with previous years. During the twelve months ending with September, there have been only 23 deaths from typhoid fever in Richmond, or about 20 per 100,000 per year, as compared with 44.1 for the lowest calendar year in the record. Moreover, there have been four months during 1909 in which there was no death from typhoid—a thing which has not happened before since records were begun in 1880.

A peculiar interest is attached to this typhoid record, in view of the fact that until recently it had been assumed that a considerable part of the Richmond typhoid was due to the water-supply. A highly interesting and valuable study which gave rise to a quite different conclusion, was presented to the American Public Health Association a year ago by Dr. E. C. Levy, Chief Health Officer of Richmond, and Dr. Allen W. Freeman, Assistant Health Commissioner of Virginia, in a paper reviewed in the Engineering Literature Supplement for Jan. 14, 1909. Mention was also made of the above-named paper in an article and editorial note dealing with the Washington water-supply, in our issue of Aug. 22, 1909.

Action by Dr. Levy and the Richmond Board of Health on the assumption that other causes than the water-supply were responsible for typhoid in that city appears to account, in considerable part at least, for the decline in typhoid there during the current year.

By a curious coincidence, it happened that improvements in the quality of the water-supply of Richmond were made unavailable by the failure of a conduit connecting some new settling basins with the pumping station. The following comment on this is taken from the bulletin named:

> In this connection it is impossible not to draw slightly upon the imagination and conjecture what would have been the effect on the minds not only of the people of Richmond and of sanitarians in general, but even upon the minds of the writers of the paper in question if the conduit connecting the new settling basins with the pumping station had not gone to pieces when first tested last fall. Had the conduit stood, we would have been getting a different water-supply for the very months during which, as stated above, the typhoid mortality in Richmond has been less than half of that recorded for any calendar year. Had this happened we ourselves could hardly have failed to feel that so marked a reduction in the typhoid fever death rate, coinciding exactly with the purer water-supply, pointed to an indisputable connection between the two, and that hence the previous deductions had been erroneous in spite of the care taken in arriving at them, while the sanitarians who had less complete opportunity of following the Richmond situation could not but have been most emphatic in this view. As it is, however, the water-supply remains the same, yet the typhoid mortality has been more than cut in half.

This Richmond incident is all the more interesting and significant when taken in connection with conclusions based on somewhat extended studies of typhoid fever at Washington, D. C., made by the U. S. Public Health and Marine-Hospital Service. These conclusions, as given in a bulletin about to be made public, confirm and extend those formulated by the same investigators a few months ago to the effect that milk and personal contact, rather than the public water-supply, appear to be the chief proved factors in the dissemination of typhoid fever in the national capital.

The successful use of putty for pointing the joints in a stone building has recently come to our notice. The First Congregational Church of Montclair, N. J., a stone structure built some forty years ago, was recently found to be in need of repointing. Estimates for the work were submitted by local contractors, and one estimate was found greatly below the others, though each estimate included a guarantee that the work would put the masonry in good shape to resist further action of the weather. On investigation it was found that the larger estimates included the erection of scaffolding, for the removal and replacement of vines, for cleaning out all open or partly open joints and for their repointing with Portland-cement mortar. The small estimate was for filling all open or loose joints with "putty," the work being done from swinging scaffolding or from a boatswain's chair as on a painter's job. With such a method the masonry could be pointed by pushing aside the vines and without removing them, as was necessary with the other work proposed.

It was also found that many joints of this same building had been pointed with putty by the low bidder twenty years ago, and examination showed that joints so pointed then were still in nearly perfect condition. They had withstood the storms of twenty years and seemed able to keep out the water and ice for another two decades.

The question arose as to what this putty was. A glance at the old pointing showed that it probably contained much white lead, and the contractor explained that for such work he purchased white lead, ground in linseed oil, by the cask as needed and worked into it enough whiting to make it easily manipulated with the fingers and pointing tools.

There seemed to be no reason why the cheaper method in these repairs should not be as serviceable as the more expensive, and work proceeded on that assumption. The putty, placed in the joints of the stonework, hardened in a few days so that it would but just receive the impression of the fingernail and it has filled the joints without shrinking.

We shall be glad to hear from any of our readers who may have had experience with this or other substitutes for cement-mortar in pointing the joints of masonry.

The above related occurrence brings to mind the question, which is beginning to be frequently raised: What is a fair allowance for annual maintenance charges on stone masonry?

It is true, of course, that massive stone masonry, such as a bridge abutment, for example, may require no expense whatever in the way of repairs for a long period of years. Yet one only has to view the condition of stone buildings in Great Britain, in a climate much milder than our own, to realize that sooner or later "the gnawing tooth of time" will make an impression on even the most durable stone. Nor need we go so far away. There are not a few masonry structures, in the eastern United States, built within the past three-quarters of a century, upon which considerable outlay for repairs has already been necessary.

This being the case, it is hardly safe or correct to ignore entirely maintenance charges in making estimates for masonry structures; but the question of what should be a proper percentage allowance for maintenance or depreciation is one on which few data exist. The subject is surely one deserving systematic investigation. If any of our readers are in possession of data on the subject we trust they may make it available to the profession.

In the comparison of different performances of condensers, or of the performances of different condensers, a term, "percentage of theoretical vacuum obtained," has been used of late. The increased attention now paid to condenser design and performance, stimulated by steam turbine users, makes a scrutiny of this term advisable by all who propose to use it. The term seems simple; the degree of vacuum attainable in any design is the reading of a barometer near the condenser minus the tension of the uncondensed water vapor on the inside of the condenser chamber. Trouble arises, however, in estimating or determining the tension of this uncondensable vapor. If the basis of this determination is unimpeachable, the value of percentage of theoretical vacuum is reliable and useful, but otherwise the figure is grossly misleading.

The author of a paper, reprinted in Engineering News, Aug. 19, describing a novel design of jet condenser, used this term assuming that the temperature of the uncondensed water vapor was simply the temperature of the mixed condensate and cooling water as discharged. A study of the peculiarities of this particular design shows that such an approximation is permissible in this case but it may be radically wrong in other designs, for instance, in the type described elsewhere in this issue. In such a case as this latter one, the term "percentage of theoretical vacuum" should not be used unless the temperature of the air and uncondensable vapor be actually measured close by the vacuum-pump connection.

It is customary with most condenser manufacturers to locate the vacuum-gage connection close by the exhaust-steam inlet, and in these cases the gage-reading is, theoretically, slightly less than if the gage connection were close by the air discharge. This results in a slightly inferior showing for percentage of theoretical vacuum and for actual vacuum.

It is interesting and important to know the limit beyond which one's condensing outfit cannot attain. It is also important to know whether inefficiency, if it exists, is due to the condenser proper or to the air pump. Now, such a separation of condenser and air-pump performance can be made with the data that allow a proper calculation of the "percentage of theoretical vacuum."

Suppose, for instance, that we have properly determined the temperature of the mixture of air and uncondensable vapor and have computed the "percentage of theoretical vacuum," finding it abnormally low. If the temperature of the air and vapor mixture is close to the temperature of the cooling water taken in, then the condenser proper is both well designed and well adjusted, whether a good vacuum is held or not. If there is a great difference in these temperatures, either the design or the adjustment may be poor. If the condenser proper is shown to be working properly, but with a low "percentage of theoretical vacuum," then the pump is causing the trouble through overloading, leakage or poor design. Overloading of the air pump may be due to excessive inleakage of air somewhere in that part of the system between the engine piston and the air pump.

There is still a third point at which we may study the action of a condenser. This is not related to the "percentage of theoretical vacuum," but rather to the expense of operating the condenser. That outfit which maintains a high "percentage value" and still discharges its cooling water with a temperature close to that of the exhaust steam is a more economical installation than an outfit that shows a high percentage value but a low temperature in the discharge cooling water. To condense a given amount of steam in the first

outfit requires less pumping of cooling water and therefore less operating expense than in the second. If the warm cooling water has some industrial value, then its value is greater in proportion to its increased temperature.

Among the larger cities of the country, Cleveland, Ohio, has taken the lead in the introduction of water meters. The results have been remarkable from many points of view, as may be seen from the brief article published elsewhere in this issue.

One thing not brought out in the article may be mentioned here. The determination of the authorities to change Cleveland from a practically unmetered to a metered city has been almost realized in a few years because of the tact used in introducing meters. By means of low charges for metered water it has been an object for domestic consumers to change from the flat or assessment rate to the meter rate basis. To prevent the low unit-quantity rate of 40 cts. per 1,000 cu. ft. or 5⅓ cts. per 1,000 gals. from embarrassing the water department, or from leading to unwise economy in the use of water, a minimum half yearly charge was fixed of $1.25 for a ⅝-in. meter on a service which under the assessment rate paid $4.50 per annum, and increasingly higher minimum charges where meters and assessments were larger.

We understand that Cleveland expects to continue its meter policy until all water is sold by quantity instead of by guess. Already it has nearly reached that desirable goal, and by its methods and results has proved that the universal meter system may be readily and speedily introduced in large cities, as had already been fully demonstrated for smaller places.

The Restoration of Traffic on Inland Waterways; Facts vs. Theories.

Why has water transportation on our inland rivers fallen to decay? The promoters of the "deep waterway" movement, who have been stirring up the country upon this matter by sundry widely advertised conventions during the past few weeks, claim that the reason is because our inland waterways are not deep enough. They unite in a demand that the United States shall borrow half a billion dollars and expend it on the improvement of inland waterways. They claim that as the result of such expenditure, fleets of steamers would be placed on these waters and a vast volume of traffic would be carried on them at less cost than if carried by rail.

Are these claims sound? What do the waterway promoters who make these claims know about the transportation business? Granted that most of them are sincere in their claims, there remains the possibility that they may err through ignorance. The literature issued by the deep waterway promoters is long on claims; but it is short on evidence; and such evidence as is presented does not bear the test of critical examination.

[redacted] transportation business, at the present day, is, like every other business, a specialty. To obtain reliable information concerning it, we must appeal to those who have expert knowledge. Nor should we be satisfied with expert opinions merely. These opinions should be fortified by concrete facts, so that intelligent men can judge whether the expert opinion is sound.

Surely before the people of the United States invest a billion or half a billion dollars to deepen waterways, they ought to obtain the most reliable advice as to whether that investment will yield the benefit its advocates claim.

Congress took this view of the matter two years ago, when the promoters of the "Lakes-to-the-Gulf" deep waterway demanded that the Government take up and execute that project. A Board of Engineers was instructed to report upon the enterprise and advise the Nation what it would cost to carry out and what benefits it would effect.

The report of that Board was presented last June, and attracted wide public attention at that time. The Board estimated the cost of a 14-ft. deep waterway from Chicago to New Orleans at 160 million dollars in round numbers, with an annual maintenance cost of about 7 million dollars; but this estimate was explicitly stated to be only an approximation based on preliminary surveys and might, therefore, be largely exceeded. Further and most important, the Board declared that the 14-ft. channel would give no benefit to navigation at all proportionate to its cost, and intimated that as the decline of water traffic in the United States has not been caused by lack of depth in the waterways, expenditure on deepening these waterways, no matter on how extravagant a scale, would not be sufficient to restore this traffic.

While this report of the Board of Engineers received some attention in the newspapers at the time it was presented, Engineering News was, so far as we are aware, the only journal in the United States to publish it in full. The report has since been printed as a public document, and with it are published a large number of appendices. Among them is a paper which, we risk little in saying, gives the most complete and authoritative information on the general subject of waterways that has appeared anywhere in the United States.

This paper is buried in small type in a bulky public document, and has been wholly overlooked by the newspaper press. The papers have been filled for weeks past with reports of waterway conventions in a dozen different sections, winding up this week with a huge convocation at New Orleans; but this official paper, prepared by a Board of Engineers commissioned by Congress to investigate the whole subject, contains more information and more *reliable* information on deep waterways than the proceedings of all these conventions put together.

The question of expenditure for waterways improvement is a business question. It is not a matter of sentiment, but of dollars and cents. The question is will it pay? That is not a question to settle with banquets and boat trips, or with speeches and red fire. It is a question to be settled by *facts*; and it is facts that are presented in this Board of Engineers' paper.

We have reprinted a large part of this paper in the present issue of Engineering News; but we urge those of our readers who are interested in the subject to obtain copies of the complete report.* This contains a great amount of tables and statistics which prove beyond the possibility of doubt the soundness and reliability of the conclusions reached by the Board of Engineers.

The whole campaign for deep waterways is based on the theory that steamboats have disappeared from our Western rivers because the channels are not deep enough. This theory is false. The Mississippi and tributaries are in far better condition for navigation to-day than they were in the most prosperous days of the steamboat business. Not only this but they are superior to the best inland waterways of Europe with all the millions that have been lavished on the latter. It is other causes than deficient channels for navigation that have driven the river steamboats out of business. It follows, therefore, that channel improvement will not restore traffic to the rivers. The United States might spend hundreds of millions to secure a few feet more depth in the Mississippi and its chief tributaries and yet the traffic would seek the railway instead of the river.

And we are not without actual experience as a guide in these matters. Some 13 years ago, St. Louis interests appeared before Congress and urged that a contract be let to a St. Louis promoter to maintain a channel 6 ft. in depth from St. Louis southward. The promoter offered to do this for a payment of $1,000,000 a year for 20 years and claimed that the river traffic would be so stimulated that national benefits amounting to $50,000,000 a year would accrue.

The promoter did not get his contract; but the Government itself, through the Mississippi River Commission, has for years past had available for river commerce an 8-ft. channel to St. Louis instead of a 6-ft. channel.

Here is 2 ft. greater depth of water than St. Louis asked for 13 years ago; but instead of the $50,000,000 annually of river traffic materializing, the steamboat business has steadily fallen away until it has now almost disappeared.

The wild claims of the Lakes-to-the-Gulf deep waterway boomers have a familiar sound to those who remember the claims made by promoters of the Samuels-Mason contract in 1896. Is there any reason to suppose the present-day promoters are any more trustworthy than those of 13 years ago? Experience has proved that 8 ft. of water will not restore commerce to the Mississippi. What evidence is there to show that 14 ft. depth would bring it back?

The stock answer of the deep waterway enthusiast is that deeper water would mean cheaper transportation. He argues from experience on the ocean or on the Great Lakes, overlooking the fact that the conditions of river transportation are radically different. He overlooks also the fundamental influence of terminals and facilities for transfer and for connections upon economical transportation; yet the matter of economy in terminal expenses is the largest factor in all transportation routes to-day. He overlooks the difference in the business organization of the steamboat owner and the railways. He overlooks the fact that railway freight rates in the United States are in many cases lower than the rates on the inland waterways of Europe, notwithstanding the low-priced labor there.

Fortunately, the popular outcry for waterway improvements has not carried all our public men off their feet. President Taft, in an address at St. Louis on Oct. 25, declared that each waterway project ought to be investigated on its merits and it should be determined whether benefit will be secured proportionate to the outlay before work is undertaken. This is sound doctrine and has already received emphatic approval in the public press.

There are waterway improvements not a few, which *are* fully justified by the resulting public benefit and which may properly be carried out at National expense. We are far from denying, either, that the deep waterway associations, with all their extravagances, have accomplished a certain amount of good by awakening interest in an important public question. If these associations could have the benefit of wise and intelligent leadership; so that instead of ignorantly devoting all their energies to agitation for huge Government expenditures on river improvement, they would take up the whole broad question how to restore waterway traffic, they might achieve a large measure of public benefit.

But to do this they must cut loose from their present plans and propaganda. They must look for the truth instead of seeking to uphold a fallacy. They must come to understand that the revival of inland water traffic cannot be accomplished by Government appropriations, no matter how enormous. Action by cities, to create public docks and piers and landings, action by states to prevent unfair competition against water transportation lines, more than all else, action by men of enterprise and ability to systematize the business of water transportation, introduce economies, and give prompt, responsible and low-priced service to the public—all these are necessary if our inland waterways are to become again important avenues of commerce.

*Document No. 50, House of Representatives, 61st Congress, 1st Session.

LETTERS TO THE EDITOR.

The Petrolithic Road System Again.

Sir:—Referring to Mr. Wardroper's letter about petrolithic pavement, appearing in your issue of Oct. 14, nothing in my letter published in your issue of Sept. 23 should be construed into an unqualified condemnation of petrolithic construction. A careful and proper reading of that letter, taken in connection with the reports which I submitted therewith, shows very clearly that it is recognized that petrolithic construction in certain places and under certain conditions has been successful. It also shows, with equal conclusiveness, that this construction is not always successful and that much discrimination is necessary in connection therewith. This is evident from Mr. Wardroper's last letter, above mentioned. If he had not referred to this construction in El Paso in his original letter the matter would not have attracted my attention.

I wish to disabuse his mind of any doubt that the photograph submitted with my original letter shows the actual condition of petrolithic pavement on Wyoming St. The broken condition of the street surface in Fig. 1 was not due to an excess of oil. On the contrary the surface of this pavement on Wyoming St. is too dry and the breaking was due solely to the heavy loads hauled over the pavement.

Since my former letter was written another piece of this construction has been laid in El Paso in the Mundy Heights Addition where the natural surface of the street was composed of sand and gravel and here the finished surface of the street has an appearance much more closely resembling asphalt or bitulithic than that on Wyoming St. In this case too much oil appears to have been used because portions of the street are rutting and folding longitudinally. Perhaps as the volatile matters in the oil evaporate and the surface becomes seasoned this defect will become remedied. The soil conditions in Mundy Heights above mentioned are, I think, most favorable for the successful construction of petrolithic pavement and reasonably good results should be secured there if the work is properly done.

The petrolithic process of construction in El Paso has been undergoing a constant modification since it began about a year ago in an endeavor to improve it. I think there is an improvement.

Yours truly, J. L. Campbell.

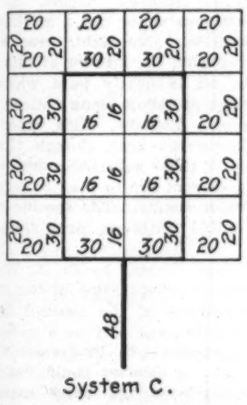
El Paso, Tex., Oct. 18, 1909.

The Economic Design of Water Distribution Systems.

Sir: The statement of "A Problem in the Economic Design of Water Distribution Systems" in your issue of Aug. 12, by Mr. Rudolph Hering and endorsed in your editorial page, was very interesting and instructive and plainly showed that System "A" was better than System "B."

I have anxiously looked for further discussion of the question, as it seems to me, that the subject is not exhausted.

To further promote discussion, let me offer another plan marked System "C" which is a compromise between A and B. This seems to answer all the requirements as laid down in Mr. Hering's article more completely than either "A" or "B" with much less iron.



System C.

PLAN A.

Weight of iron, 9,581,000 lbs.

PLAN B.

Weight of iron, 10,974,000 lbs.

PLAN C.

Weight of iron, 8,301,000 lbs.

Percentage of excess of iron in A over C = 15.4%

Percentage of excess of iron in B over C = 32.2%

If a block length of the largest mains should be put out of service by accident, and should a conflagration then occur at any point, a proper equipment of shut-off gates being assumed, System C would deliver a larger quantity of water than either Systems A or B.

Yours truly,

C. D. Ward.

702 St. Nicholas Ave., New York, Oct. 9, 1909.

[Proof of the above letter was submitted to Mr. Hering and we append his reply as follows.—Ed.]

Sir: The letter of Mr. C. D. Ward regarding the Economic Design of Water Distribution Systems, apparently indicates that the subject matter of my letter in your issue of Aug. 12 was not as generally appreciated as I believed. I was only concerned in stating, at your invitation, the fundamental principles of water-supply distribution, and the example used for illustration was but an actual case discussed some years ago.

That the example given by Mr. Ward, which is based upon those principles, shows even greater economy, only further proves the importance of an engineer's making a proper analysis of all his problems. Some of these problems appear so simple to the layman, that they are often undertaken and solved by Council Committees alone, without engineering cooperation. In this way, as shown by Mr. Ward's figures, a "layman engineer" may innocently add about one-third to the cost of a distribution system, or a part of it, without gaining any advantage whatever in efficiency.

Yours truly, Rudolph Hering.

170 Broadway, New York, Oct. 19, 1909.

The Failure of the Dam at Fergus Falls, Minn.

Sir: I have before me your issue of Oct. 14, with a description of the failure of the dam of the city electric light plant at Fergus Falls, Minn., written by Mr. Franklin McMillan. Mr. McMillan's description of the whole proposition is a very intelligent one, and covers the ground thoroughly. There are some statements made in this article which are incorrect, due to the fact that they are simply quotations of what he heard. Take for instance where he says:

> It has also been stated by parties familiar with the general conditions, under which the work was being carried on, that the borings were very unsatisfactory, and the conclusions drawn from them very unreliable.

This is not correct. You and your readers know well enough that in any instance where municipal authorities or a city council undertake any kind of work, more especially that of an engineering character, every member of the council, as well as every taxpayer and citizen, considers himself a "natural born" engineer. You know also that in such cases there are always two factions, one for and the other against the project, and I will frankly say that Fergus Falls was no exception to the rule. Doubtless the persons with whom Mr. McMillan spoke and whom he quotes were those who were against the project, and to a certain extent responsible for the failure of the dam.

I will say that the borings were properly done and the sub-strata found to be in accordance with the report I made, and the excavations for the foundations proved my report to be correct. The bottom, on which the dam rested, was what is commonly known as "hard-pan" and was so hard that it would have been impossible to have driven sheet piling of any kind without jetting.

I could write pages on this proposition, but do not propose to do so. All I desire at this time is to place before your readers just what, in my opinion, caused the failure of the dam, and which can be readily understood after a careful study of Mr. McMillan's article.

That a great many springs were encountered in the excavation is true, as is most generally the case in every river bed that has not a rock bottom. That all of these springs disappeared except one (which is almost accurately indicated by X, in Fig. 2, of Mr. McMillan's article) is also a fact, and I will quote from Mr. McMillan as follows:

> One spring, which had not disappeared continued to give trouble up to the time of placing the concrete base in the tail race, and it is reported that considerable difficulty was encountered in stopping it sufficiently to permit the concrete to set. What means were adopted to accomplish this the writer was unable to learn.

Other than the water which was being discharged by this spring, and which had to be pumped out, there was no trouble encountered from the spring when the floor of the wheel pit (termed as the base in tail race by Mr. McMillan) was being put in. The floor of the wheel pit was of independent construction from the other parts of the dam, from the fact that all of the footings and foundations of other portions of the dam were put in and brought up to the elevation of the bed of the river before the floor of the wheel pit was laid. This floor was 18 ins. thick and made of concrete, of the proportions of 1:3:6, and was so laid that the finish on all sides terminated at the point where the spring was discharging, and an orifice was left to allow the spring to discharge freely at all times.

My contract was made with the Water and Light Commission of the city of Fergus Falls, and read as follows:

> That for and in consideration of the sum, etc., etc., the party of the first part agrees to prepare plans, specifications and estimates for the building of hydro-electric plant, which the parties of the second part propose to build, also to do all the engineering work necessary to build said hydro-electric plant by being on the work personally during all the time the foundations for the dam are being put in, and to furnish a competent resident engineer who will be on the work from the start to completion of said dam.

I was personally on the work until all the foundations were put in, and, in accordance with my contract with the city authorities, I left a competent engineer to see that the plans and specifications were carried out.

The city council also employed an engineer, who was on the work from the time construction was started until the completion of same, especially for the purpose of seeing the concrete mixed in the proportions as called for in specifications, and to supervise generally the construction.

When I gave up the personal supervision of the work, I instructed the engineer I left in charge that under no circumstances whatever was he to try to stop, or allow any one to attempt to stop, the orifice in the concrete floor of the wheel pit, through which the spring was discharging. Also, that the specifications were to be lived up to the letter, and that in case any of the city officials should undertake to countermand my instructions he was to immediately leave the work and inform me. This he did not do.

On my next visit to the work, which was about three weeks after the time the foundations were put in, the engineer representing me on the work told me that certain of the city officials visited the work and insisted and gave orders to their engineer to the effect that the contractor must close the orifice, through which the spring was discharging, and stop the flow of water; and just before pulling the pumps the contractor sent his foreman into the wheel pit with several sacks of cement, which were crowded into the hole and the orifice practically sealed, to the satisfaction of the city authorities.

Your readers will appreciate that artesian water, or any spring discharging under pressure, must have a vent, and they doubtless will agree with me that when I provided an orifice in the floor of the wheel pit, through which this spring had a vent, that I had done all that was within engineering possibilities under such circumstances. They should agree with me that after city officials went there and insisted that this orifice be closed, without first consulting me, and saw to it that the contractor closed it, I was not responsible for anything that might develop through this spring breaking out in some other place.

In 1904, I designed and constructed the Riverdale Dam for the Apple River Power Co., across the Apple River in St. Croix County, Wisconsin.* This dam rests on a sand bottom, and instead of having one spring to encounter there were at least half a dozen springs discharging very copiously in the wheel pit, which were taken care of in a similar manner as the one spring at Fergus Falls. In the Riverdale construction, as many as three springs were conducted to one orifice, and there are (if I remember correctly) three orifices through which the springs are discharging, the orifices being formed by pieces of pipe brought through the concrete floor of the wheel pit. It will be seen, therefore, that providing an orifice for the springs to discharge through, thereby giving them vent and removing any chances of cutting, or undermining, is not a new idea, and was not first put into practice at Fergus Falls.

By carefully examining the half-tone cuts, as well as the description in Mr. McMillan's article, from which I quote as follows:

> The tail race for the unit in operation was described to be running full while the water in the other tail race and in the main river channel was at its normal stage, some five or six feet lower,

and by looking at Fig. 2, where point X marks the location of the spring, it will be discovered that this is the wheel pit of the unit which was in operation. It is also the wheel pit in which the spring was discharging before it was ordered stopped by the city officials.

To my mind there is not the slightest doubt that the stopping of the orifice through which this spring was discharging, compelled the water to find some other outlet, and in so doing undermined some of the foundations. Whether it was the pier, 10 ft. thick, dividing the wasteway from the wheel pit, or whether the spring worked under the forebay and back into the mill pond no one will ever be able to determine. But there is one thing of which I feel certain, and that is that the undermining of the foundation did not happen in one night, but had been going on for months, until the foundations which were undermined gave way, due to the weight of the concrete after the support had been washed from under them. This settling allowed the masonry to break and gave vent to the water stored in the mill pond, which, of course, entirely wrecked the plant.

I note that Mr. McMillan says that concrete was "fairly good, and suitable for the work," but that "the quality of the concrete in the heavy walls at the sides of the power-house was not good, being rather porous." Of this poor quality of concrete I was not cognizant. My specifications called for concrete of 1:3:6 proportions, throughout the entire work. The city of Fergus Falls had an engineer on the work to see to it that the concrete was mixed according to specifications, and if he allowed the contractor to mix poor concrete I do not see that I can hold myself to blame.

I visited Fergus Falls, and the plant, somewhere about April 1, 1909, and everything looked in good order. The ice had not all gone out of the river, and therefore I was unable to make any examinations, but superficially everything looked to be in good order.

Since the failure of the dam I had a talk with the contractor, who was on the job all the time, and he told me that in July, 1909, he visited the plant and was very much surprised that those in charge of the plant were allowing the north embankment to become saturated by some springs that were flowing out of the north bank; also that he walked over the bank and went in to his shoe tops in several places. I mention this so as to be able to point out that the plant lacked proper management, and that evidently no examination was made at any time of the plant after it had been started.

Just before starting up the plant I called for, and had a conference with the Water and Light Commission, and told them that the plant would have to be carefully watched for at least two years; that the banks

*Engineering News, Oct. 12, 1905.

were new and the entire plant new, and that on account of the presence of springs the plant ought to be watched for any indications of cutting, which would be indicated by the water being roily. I also told them that their superintendent was not a fit person to have charge of the plant and it was criminal negligence to have such an incompetent person in charge of the plant. As far as I know a competent man was never put in charge of the plant as superintendent.

I quote again from Mr. McMillan's article, as follows:

The only other irregularity that was noticed was that one sluice gate never closed completely, and there was always a discharge of water through this small opening.

The sluice gates which were specified and which were put in the dam were two 60-in. Coffin sluice gates with brass-to-brass faces, and these closed absolutely tight when the mill pond was first filled. The mill pond was subsequently drawn down and refilled, which was in November, 1908.

I was not aware that this gate was leaking until I made a visit to Fergus Falls some time in April, 1909. Then I was told that the gate would not close, due to the fact that when the pond was drawn down in November the limb of a tree (or something else) had got wedged between the gate and the frame and they could not close the gate, but that it was their intention to draw the mill pond down after the spring freshet and get this limb out.

Provisions were made for keeping logs and other heavy timbers from getting directly in front of, or against, the flood gates by a trash rack of heavy construction. It appears as though the limb had got jammed or held by the trash rack, and it would have been a very easy matter to have drawn down the mill pond and removed this limb (or whatever it was), as provisions were made whereby a man could stand on top of the trash racks, to clear them, without being in danger.

The wrecking of the dam is a very unfortunate affair, and one which does good to nobody.

It hurts every construction of a similar character, whoever is the engineer. It probably hurts most of all the engineer who designed and supervised the work, whether or not that engineer is responsible through lack of ability.

For the failure of the Fergus Falls Dam I do not hold myself responsible in one iota. That the dam stood for ten months the pressure that it was designed to bear, including the spring freshet, I hold is conclusive proof that the design is correct.

That meddlesome city officials obstructed the discharge of the spring by having the orifice (which was left by me for the spring to discharge through) closed, causing this spring to seek an outlet elsewhere, and in so doing undermined the foundations of the dam, causing it to collapse, is a matter for which I do not hold myself in the least responsible.

Thanking you for the use of your valuable space, I am,

Yours truly,

R. S. Feurtado, Consulting Engineer.

400 Monadnock Block, Chicago, Oct. 19, 1909.

Notes and Queries.

The article on "Feeder Lines and Conductors for Electric Railways," on p. 447 of our issue of Oct. 21, was an abstract of a committee report presented at the annual meeting of the American Street and Interurban Railway Association at Denver, Colo., Oct. 4 to 8. The footnote stating this fact was accidentally omitted.

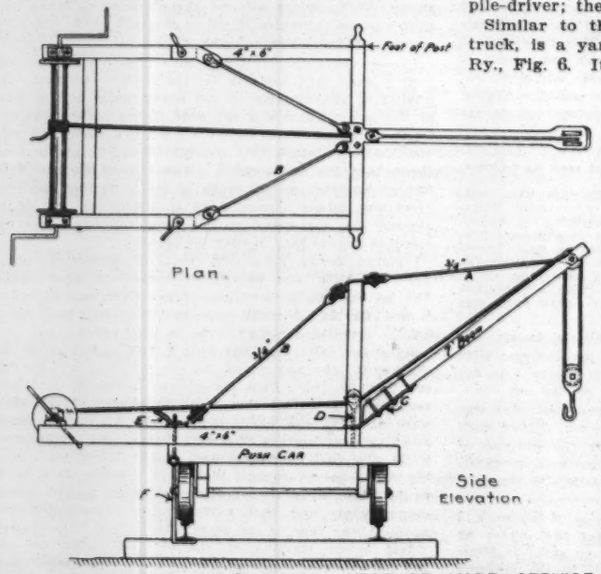


FIG. 2. PUSH-CAR DERRICK FOR STORAGE YARD SERVICE; ST. LOUIS, IRON MOUNTAIN & SOUTHERN RY.

Portable Derricks in Railway Use.

The little push-car derrick shown by Fig. 1 herewith is in use on the Chicago & Eastern Illinois Ry., in the work of the bridge gangs. Mr. A. S. Markley states that it will pick up three 8 x 16 stringers 32 ft. long. The arm is guyed by ropes in preference to rods. The hand hoist is anchored down to the rail by a chain and hook when hoisting, to prevent tipping. It has proved a great labor-saver.

Fig. 1. Push-Car Derrick Used in Bridge Work on Chicago & Eastern Illinois Ry.

Fig. 3 is from a picture of a very similar push-car derrick for yard use, on the St. Louis Division of the Louisville & Nashville Ry.

A small boom-derrick adapted to be mounted on a push-car, shown by Fig. 2, is used on the St. Louis, Iron Mountain & Southern in and around storehouses and yards. It is considered too heavy to take out on the line for bridge work. The fixed-arm crab, Fig. 4, is intended for the use of bridge carpenters; its design is credited to S. C. Tanner, of the Baltimore & Ohio Ry.

A larger portable derrick, meant to be set on a flat car, is also used on the St. Louis, Iron Mountain & Southern. This is shown in Fig. 5. Its hoisting line is handled by a locomotive or a pile-driver; the topping lift is hauled by hand.

Similar to the last, but mounted on its own truck, is a yard derrick of the Missouri Pacific Ry., Fig. 6. It has a hand winch for the hoisting rope. The mast is stepped to swing horizontally, as is also that of the previous derrick, Fig. 5.

A much simpler hoist, of smaller range of utility, is in use on the Southern Indiana Ry. It comprises a hand winch or windlass without derrick arm, mounted on the short end of a frame pivoted on a push-car. This is adapted only for hoisting up to a height of about 2 ft. above track level, but proves convenient in lifting and moving large timbers alongside the track.

These handy devices are described by a committee of the American Railway Bridge & Building Association in a report made at the Jacksonville convention, Oct. 19.

Convention of the American Electrochemical Society.

The Sixteenth General Meeting of the American Electrochemical Society was held in New York City, Oct. 28, 29 and 30. The first day's session was devoted to professional papers and a lecture, and was held at the Chemists' Club on 55th St.

The first paper presented, "The Titanium Arc," by Mr. W. S. Weedon, of Wilmington, Del., showed a few results of researches made several years ago at the research laboratory of the General Electric Co., in the search for arc-lamp electrodes of high luminous efficiency. Of all the materials available, titanium compounds gave the greatest candle-power per watt of energy supplied. Of the compounds available in the market, titanium carbide, without excess of carbon and even with some metallic titanium and iron, proved the most satisfactory.

The light of a titanium arc comes from the vapor stream between the terminals. Only the terminal from which current flows to the arc need be of the titanium carbide. It was found that the luminous vapor had a marked structure, being cylindrical. No light, practically, came from the vapor on the interior of this shell. The light given off is nearly pure white—only the slightest tinge of yellow being noticed on viewing the arc from a distance. This paper dealt only with direct-current arcs, though titanium carbide is one of those substances which allows an alternating-current arc to play between two carbide electrodes simply. The specific energy consumption is 0.51 watts per mean spherical candle power.

"The Element Boron," by Dr. E. Weintraub, of Lynn, Mass., described some of the recently discovered properties of the element boron which formerly was isolated only as a greenish brown, amorphous powder. In that state the physical properties of the element could not be studied. This paper related the early experiments of Moissan in which boron trioxide was chemically reduced. This eminent investigator got a substance which he claimed had 93% boron, with the rest of aluminum, magnesium and nitrous oxides. Dr. Weinstraub found that Moissan's 93% boron

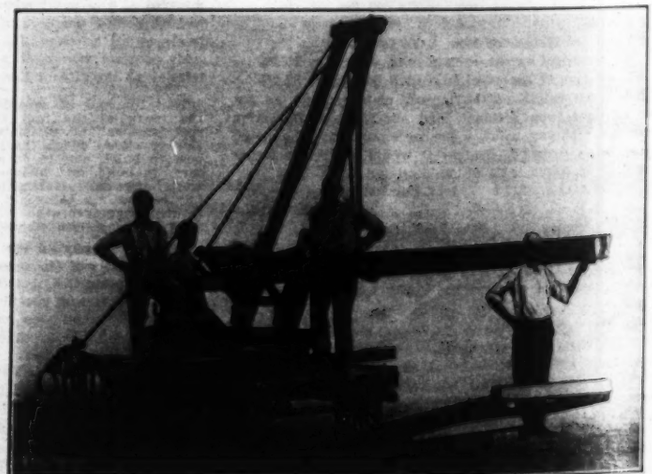


FIG. 3. PUSH-CAR DERRICK ON LOUISVILLE & NASHVILLE RY.

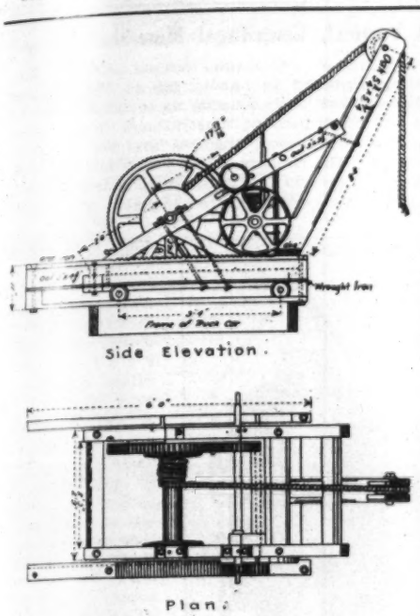


Fig. 4. Fixed-Arm Portable Derrick for Bridge Carpenters.

contained 15% oxygen and was really only an oxide. After many trials the author of the paper developed a method of injecting boron chloride into an arc which was surrounded by hydrogen vapor. The boron chloride was reduced to boron and hydrochloric acid in the process and the boron came out on the walls of the hydrogen chamber and also went to the arc terminals. The boron deposited on the terminals alloyed with most metals but it was found that by using copper with an alternating-current arc this action could be entirely prevented.

The fused boron obtained is very hard, being inferior only to diamond. It has the peculiar fracture and general appearance of black diamonds. It has a high resistance to passage of electric current, but this drops in a remarkable way. Between room temperature and red heat the decrease in resistance has a ratio of 2,000,000 to 1. That is, the electrical conductivity doubles for every increase of about 17° C. Boron was found to melt at atmospheric pressure somewhere from 2,000° to 2,500° C. and to boil at nearly the same temperature. In a vacuum, it was found that the boron sublimed off without melting. The great increase in electrical conductivity could be controlled by dissolving a few tenths of a per cent of carbon in the boron. This lessened the change as desired. It was found that by dissolving slight traces of the pure boron in carbon, that carbon of "metallized" form was formed, having a positive coefficient for change of electrical resistance with temperature, whereas both elements alone had negative coefficients.

"The Preparation of Silendum," by Messrs. S. A. Tucker, H. F. Kudlich and E. M. Heumann, of New York City, was presented by Prof. Tucker. This was the account of several qualitative experiments carried out in an electric furnace at Columbia University. "Silundum," it appeared, was the name given to carbon "soaked" at a high temperature in an atmosphere of silicon vapor until the carbon became partially converted into carborundum. The most valuable property of silendum appears to be its ability to stand a high temperature in the open air without oxidation. As it is a conductor of electricity this property makes its use as a resistance material valuable.

The lecture by Prof. Edgar F. Smith, of the University of Pennsylvania, was on "Advances in Electrochemical Analysis." Prof. Smith is well known in this country and abroad as one responsible for most of the new deposition methods of rapid analysis, and his lecture was largely a historical review of these developments. The different steps of the years back were illustrated by typical experiments with typical apparatus, from the laboratories of the University of Pennsylvania.

He stated that it was now thirty odd years since he became interested in these methods, and that a beginning was made because of his dislike for methods of copper analysis in vogue. He followed a suggestion of Walcott Gibbs and passed current from two bichromate primary cells through the copper solution to throw down the copper. In the course of time other troublesome separations, like that of cadmium or uranium from potassium or sodium salts, were performed in an hour whereas the most skilled chemists needed days by the old methods. In 1901 the lecturer found that they were able to cut the time of their electro-analyses from hours to minutes by agitating the anode and using heavier currents. The most satisfactory results came from rotating the anodes and this has become a well standardized practice. Another great advantage lies in the consistent accuracy which beginners are able to secure.

Prof. Smith also outlined the development of Walcott Gibb's suggestion to use a mercury cathode for the separation of troublesome metals. Here the amalgam formed could be weighed or the solution could be titrated for its content of residue. Innumerable interesting determinations were cited and the apparatus for many of them were exhibited. The most interesting case, perhaps, was the isolation of a radium salt from radiferous barium chloride. The presence of the radium was known from the wonderful electrical properties of a watch crystal bearing the residue from evaporating the isolated radium-salt solution, though it could not be seen on the crystal.

The second day of the convention was entirely occupied by trips through the several chemical and manufacturing plants of Bayonne, N. J. The evening was taken for a banquet. The presentation of professional papers was continued on the third day in Earl Hall, Columbia University.

Nearly half of this session was taken up by the discussion of four papers. (1) "The Laws of Electrode Losses in Electric Furnaces," by Mr. Carl Hering, of Philadelphia; (2) "Furnace Electrode Losses," by Mr. C. A. Hanson, of Schenectady, N. Y.; (3) "Electrode Losses and Furnace Efficiency," by Dr. E. F. Roeber, of New York City; and (4) "A New Method of Measuring Mean Thermal and Electrical Conductivity," by Mr. Hering. All these centered about a proposition, advanced six months ago, by Mr. Hering that by proportioning the electrodes and the current of a furnace so that the electrodes at or near the interior of the furnace were hotter than the furnace, there would be a flow of heat inward from this part of the electrodes to the furnace and therefore none could flow from the interior of the furnace to the exterior through the electrode. The author with this starting point laid down and demonstrated several "absolute laws" of the losses by heat conduction through electrodes leading into an electric furnace. Two of these were:

(1) The total loss through the cold end of an electrode is equivalent to the sum of the loss by heat conduction alone (when no current flows) and half the $I^2 R$ loss.

(2) This loss will be least when the loss by heat conduction alone is made equal to half the $I^2 R$ loss; the total loss would be then equal to the $I^2 R$ loss and no heat would be conducted from the interior of the furnace.

The author's demonstrations and later deductions were not very gently criticised, many claiming that his work was vitiated by neglecting proper consideration of the change of rate of heat conduction in the electrodes. The general basic statements were held to be obvious.

"The Practical Conductance of Electrolytes," by Messrs. J. W. Richards and W. L. Landis, of South Bethlehem, Pa., was an account of an experimental study on the added conductance of a bath, in which two parallel plates were immersed, as the proportion of liquid not included in the direct path between plates was increased. It was found that an increase up to 40% was secured, but the effect was constant after that

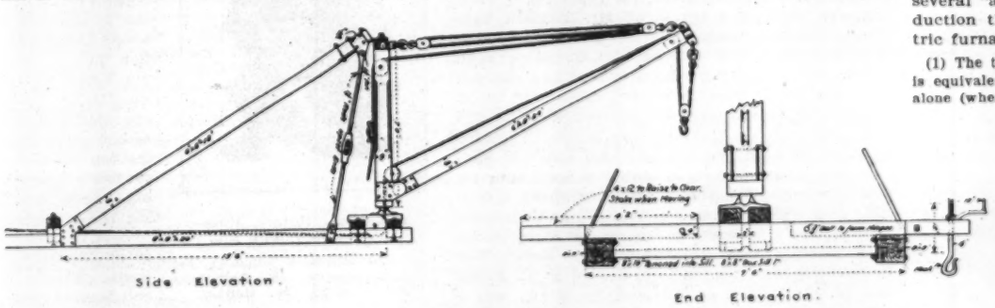


FIG. 5. PORTABLE DERRICK FOR SETTING ON FLAT CARS; ST. LOUIS, IRON MOUNTAIN & SOUTHERN RY.

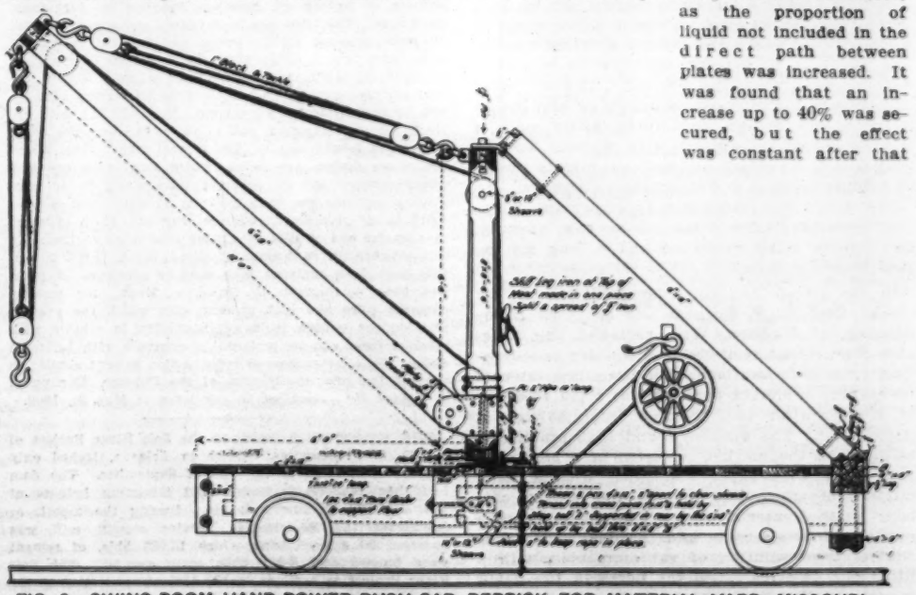


FIG. 6. SWING-BOOM HAND-POWER PUSH-CAR DERRICK FOR MATERIAL YARD, MISSOURI PACIFIC RY.

point irrespective of the proportion of liquid in direct and indirect paths. Similar results were obtained with masses of metal through which current flowed.

Mr. Maximilian Toch, of New York City, in "A New Theory for Corrosion," described a few successful attempts to induce persistent passivity in iron or steel plates by making the samples the cathode of a bath of sodium carbonate with a heavy current flowing at a small voltage. The few who discussed the paper believed that it was a case where a surface of pure iron had been left. This elimination of all local electrolytic couples was believed to have inhibited corrosion.

The paper "Alloys of Copper With Electrolytic Iron," by Prof. C. F. Burgess and Mr. James Ashton, of Madison, Wis., showed the results of a study, under a grant from the Carnegie Institution, of the physical properties of iron-copper alloys. It was found that small percentages of copper increased the tensile strength of pure iron and there seemed to be also the general characteristics of the nickel steels, except as to corrosion. A 1.5% copper alloy gave the greatest promise. No such benefit resulted from copper-steel alloys, as the carbon present seemed to interfere.

In the paper "Power for Electrolytic Copper Refining," Mr. W. L. Spalding, of Buffalo, N. Y., analyzed in a very general way the conditions of electrolytic refining at the smelter and in the East, and compared the equipment best suited for economy under the different conditions. It was stated that the cost of electric energy was 20% of the total cost of refining, but there were conditions prevailing that made cheap power and maximum economy possible—such conditions as uniformity of load and attendant benefits.

"Electro-Cementizing; A Process for Simultaneously Annealing, Cleaning and Zinc-Coating Wire" was the title of a paper by Mr. Alfred Sang, in which he described a newly invented process for "galvanizing." It was based on the discovery of one Dumas in 1865 that iron could be coated with zinc by heating to redness in oxide of zinc and powdered charcoal. In Mr. Sang's process the iron wire was passed through a furnace packed with zinc oxide and powdered coal. The wire was heated by the passage of electric current to just above its recalescence point. This cleaned the wire of surface dirt as it was wiped by the surrounding mixture. The zinc oxide was reduced and went onto and into the iron wire forming a tenacious, rust-resisting coating. As the iron cooled it was annealed. The whole process is still in uncommercial form.

"The Manufacture of Air-Saltpeter by the Process of the Badische-Analin and Soda Fabrik," by Dr. C. Schönherr was a description of a new process, for oxidizing the nitrogen of the air, for which great yields were claimed. In theory, a steady alternating-current arc of high current density was maintained in a tube through which hot air was blown with a whirling motion. The furnaces in present use had an arc of 5 meters length requiring 600 HP. The air, after oxidation of the nitrogen, is drawn off and cooled under steam boilers and dilute nitric acid is later produced by contact with water. This is poured over limestone and calcium nitrate forms. The dilute solution is evaporated to dryness.

The small but commercially important "dry-cell" received much attention at this meeting, two papers being presented and a long discussion following them.

In the paper "Certain Characteristics of Dry Cells," Prof. C. F. Burgess and Mr. Carl Hambuechen, of Madison, Wis., reviewed the desirable characteristics of the common dry cell—freedom from deteriorations with time, low internal resistance, minimum polarization, rapid recovery of voltage after use, freedom from leakage of liquids, etc. The authors found that practically all cells on the market consisted of a zinc shell well lined with paper and filled with a loose mixture of manganese dioxide and broken carbon. In the center of the solid mixture, a carbon rod serves as electrode and terminal cells. The electrolyte—a solution of sal ammoniac with a little zinc chloride—filled the pores of the paper lining and the intersection of the core mixture. Cells of such construction varied from good to worthless, and the authors believed that purity of materials was the determining factor. A fair energy rating for a good cell was given as 30 watt-hours.

Mr. F. H. Loveridge in the paper "Dry-Cell Tests," described a line of tests developed for judging samples of dry cells and stated some results found. He argued for new standard ways of rating in place of the present ways by dimensions or by value of short-circuit current. A desirable rating was believed to be in ampere or watt-hours.

It was found on short-circuit tests that the permanent drop of potential was rapid, but by closing the circuit of a cell on say ten ohms the drop was nearly along a straight line. The current rating increased as the time of service was longer and the current smaller; if the resistance was cut down so that a drop to one-third initial voltage resulted in one hour only seven watt-hours was yielded. If the resistance was increased so that the time was ten hours, then the yield was 24 watt-hours. On a test for intermittent service it was found that the dry cells would yield more energy if a heavy current was drawn than with a light one, but that they would have a smaller life. The poorer energy rating on a long life was attributed to internal deterioration with time.

At the close of the discussions on dry cells the meeting voted to request the council of the society to appoint a committee which should formulate standard tests that would allow ratings to satisfy service conditions.

Mr. E. R. Taylor, of Penn Yan, N. Y., in a paper on "A Large Iron-Ore Furnace," showed a design, not yet constructed, for replacing a blast furnace. Several features of Mr. Taylor's successful carbon-bisulphide furnaces were embodied. There was a core of charcoal around which, at the sides of the furnace, was the ore. This ore was forced down the sides and in at the bottom just above the electrodes. The CO_2 from the charcoal column was to be circulated by fans through the ore and the charcoal successively several times to obtain a maximum reducing effect. The electrodes were above a crucible into which the molten iron fell as reduced.

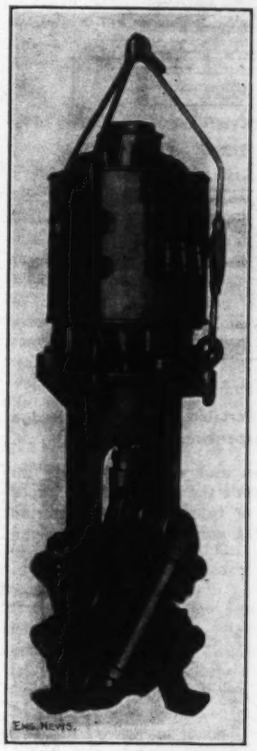
Two papers discussing laboratory experiments with calcium were presented. The first, "The Preparation of Calcium," by Messrs. F. C. Frary and W. L. Badger, of Minneapolis, Minn., was a collection of notes on the electrolysis of molten calcium chloride for the isolation of the pure metal. The second paper, "On Calcium Carbide," presented a few studies on the behavior of calcium carbide in the presence of lime.

BRIDGE RECONSTRUCTION on the Northern Pacific Ry. is being carried on in a systematic manner with the purpose of having all openings spanned by permanent structures. The total length of timber structures replaced by steel bridges, embankments or in other permanent form from July 1, 1885 (when the work was commenced) to June 30, 1909, has been 112.75 miles. During the year ending June 30, 1909, there were 90 bridges replaced and 16 abandoned; of 46 bridges, 29 (5,479 ft.) were replaced by embankments, and 17 (3,268 ft.) by truss, plate girder and I-beam spans. The annual report, from which the above figures are taken, states that there are now under construction on operated lines 2,302 ft. of steel girders on concrete piers, 835 ft. of steel trestles, and 1,616 ft. of reinforced concrete trestles. It is expected that by the end of 1911 all timber structures on the main line between St. Paul and Livingston, Mont. (1,007 miles), will have been replaced with steel or concrete. A plant has been established at Glendive, Mont., for making concrete piles and slab girders with which the present pile bridges (which it is not necessary to replace with steel girders) can be replaced in concrete with ballasted decks. This latter type of construction is very similar to that of the concrete trestles of the Chicago, Burlington & Quincy Ry., described in our issue of May 20, 1909.

THE ROOSEVELT DAM, on the Salt River Project of the U. S. Reclamation Service in Arizona, lacked only 15% of completion at the end of September. The dam had then reached maximum and minimum heights of 195 and 132 ft. above datum. During the month of September the Reclamation Service cement mill was operated 26 days, during which 13,023 bbls. of cement were burned and 8,901 bbls. were ground. The Salt River Project as a whole lacked 18% of completion at the end of September.

A Vertical, Centrifugal Mine-Shaft Pump.*

A type of two-stage, vertical, sinking-shaft pump designed to handle 120 to 180 gals. per min. against heads varying up to 225 ft. is shown in the accompanying illustration. The design is unique and several features are worthy of attention. The runners are of bronze and are made in two pieces to facilitate finishing their interior water passages exactly to template. The glands are of brass; the shaft is of forged steel; and the casings and side plates are of cast iron. A 20-HP. motor, usually direct-current, drives the pump rotor at 1,700 r. p. m., although an alternating-current motor can be substituted if desired. A flexible cable connection runs to the shaft house for the electricity supply, but the starting box (or compensating starter for an alternating-current motor) is mounted directly on the side of the motor.



A Vertical, Rotary, Mine-Shaft Pump, with Electric Drive.

(Designed by the Buffalo Steam Pump Co., Buffalo, N. Y.)

The thrust of the pump is balanced as the suction inlet of the first stage is at the bottom and the inlet to the second stage is at the top. The motor has a supporting thrust bearing heavy enough to bear the weight of all the moving parts. This is a ball-bearing type, on top of the whole unit, and runs submerged in oil. This is the only bearing that is oiled, though the upper pump gland carries a grease cup.

When in use in a mine shaft the motor is protected from stones dropping down by a conical cover made of ¼-in. boiler plate and slung below the ring on the three rods supporting the pump from the tackle. A similar plate is attached to the bottom of the machine to guide it down the shaft and to prevent its catching on cross timbers. There is no need of special provision for priming as it is evident that the pump can be lowered until the pump end is entirely submerged for starting. Water is taken through about 10 ft. of heavy, marlin-wound, rubber hose, connecting with the suction inlet. The lower end of the hose should carry a large strainer. The delivery is through a 2½-in. pipe fitting, and connection may be made by hose to any existing lines.

PROGRESS ON PANAMA CANAL LOCK CONSTRUCTION is reported as follows by the "Canal Record" of Oct. 20:

Concrete Laid in Gatun Locks.

	Cu. yds.
To Aug. 28 (seven days)	1,298
September (28 days)	11,934
Oct. 1 to 9 (nine days)	6,014
Oct. 10 to 16 (seven days)	6,692

The daily average for August during the 7 days after work started was 185 cu. yds.; for September, 459 cu. yds.; for the first nine days in October, 668 cu. yds.; for the week ended Oct. 16, 956 cu. yds. On Oct. 13 the thousand yard mark for a day's work was passed. The concreting gangs work in two 6-hour shifts and on Oct. 3 Sunday work was begun.

At the Pedro Miguel locks, concreting began on Sept. 1 and 5,146 cu. yds. had been laid up to Oct. 16. Operations are delayed at Pedro Miguel by delay in the installation of the concrete-handling cranes.

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*From information supplied by the Buffalo Steam Pump Co., Buffalo, N. Y.

A COAL MINE EXPLOSION at the colliery of the Rhymney Iron Co., at Glamorganshire, Wales, Oct. 29, killed 20 miners.

A FERRY BOAT CAPSIZED ON ITS TRIAL TRIP Nov. 2 in Guayaquil Harbor, Ecuador. Of the 22 passengers on board, 18 were drowned. The boat was launched on the day before the accident and had been in service only about an hour.

CLOUDBURSTS IN MEXICO in the State of Tabasco, Oct. 25, caused several rivers to overflow their banks and extensively damaged property in a number of towns and in farming districts. A total of 32½ ins. of rain fell in three weeks.

A SPEED TEST ENDED IN A WRECK on the new electric railway between Villefranche and Bourg-Madame, France. Six persons were killed and twelve others injured.

A FREIGHT LOCOMOTIVE BOILER exploded Oct. 30 on the Coal & Coke Ry., at Yankee Dam, W. Va. Five men were killed.

THE STEAMER "HESTIA" WAS WRECKED Oct. 2 by running aground at Old Proprietor Ledge, Grand Manan Island, New Brunswick. Her crew consisted of 37 men and there were four passengers. Only six of those on board were saved. The "Hestia" was one of the ships of the Donaldson Line and was bound from Glasgow, Scotland, for St. John, N. B. Her gross tonnage was 3,790.

AN EXPLOSION IN A COAL MINE of the Cambria Steel Co., two miles from Johnstown, Pa., Oct. 31, killed twelve men. The accident occurred at the end of the day's work when only 15 men were in the mine. Three of these men escaped by climbing the emergency ladders in the main shaft. The twelve victims were imprisoned behind a heavy fall of rock caused by the explosion and suffocated before the rescue parties could reach them.

FIRE DESTROYED AN ORPHANAGE at Lynchburg, Va., Oct. 26. Five children were burned to death. The fire occurred early in the morning, when all of the twenty-five or thirty child inmates were on the second and third floors, and was not discovered until the whole lower floor and basement were enveloped by the flames. Most of the children escaped by getting out on the roof of the veranda and descending a ladder.

A BUSINESS BLOCK WAS BURNED at St. Johnsbury, Vt., Oct. 30, causing the death of nine of the tenants. The building known as the Citizens' Savings Bank block, was of brick, four stories high and was a combination of stores, offices, assembly halls and tenements. The fire was discovered at four o'clock in the morning on the ground floor after it had gotten a considerable start. An open elevator well helped to quickly spread the flames to the upper floors. The firemen were unable to check the flames and the building was practically destroyed. The third and fourth floors were devoted to tenements and it was there that the loss of life occurred. There appears to have been no fire escapes, and the fire department had no ladders long enough to reach the third-story windows.

AN EXPLOSION OF A WATERPROOFING compound to be used in concrete block, on Oct. 28, at La Porte, Ind., killed one man, severely injured another and partially destroyed a block factory. The nature of the compound or the cause of the explosion are not known.

THE WRECKAGE OF THE PEORIA BRIDGE, the series of concrete arches that collapsed into the Illinois River on May 1st last (Eng. News, May 13, 1909, p. 529), has not been removed from the river bottom where it has been a serious obstruction to navigation. The federal authorities have recently ordered the city to clear out the channel and advertisements for bids for the removal are now in the press.

A BURGLARIOUS SAFE TEST was made at Perth Amboy, N. J., Oct. 22, on a manganese steel bank safe.

The body of the safe was a single casting of manganese steel. The walls had a minimum thickness of 3 ins. The door was circular and opened into one end of the cylindrical body. It was, like the safe itself, a single casting of manganese steel. Its general shape was that of a frustrum of a cone but its sides were not continuous but broken up into four steps.

The innermost of these steps carried six heavy lugs which, in the locked position, engaged corresponding lugs in the safe body. In closing, the door lugs passed through between those on the safe; then the whole door was rotated by the closing crank and the door lugs slid in behind the safe lugs. A slight pitch was given the lugs so that a screw-thread action was obtained which drew the door very tightly shut. Bolts projecting radially from two of the door lugs were controlled by a time lock sunk in a recess on the inside face of the door and, when projected into their sockets, prevented the door's rotation. A secondary or day lock was provided in the form of a single bolt placed just back of the outer "step" of the door and controlled by a two-dial combination on the front. The bolts have no part in resisting a force tending to move the door outward but simply prevent its rotation.

The special feature of the safe was the air space, known as the explosion chamber, between the two outer steps of the door. The outer step was connected with the second only by five peripheral and one central neck of metal, leaving a space of about 2 or 2½ ins. Each neck had a sectional area of about 10 sq. ins. The two outer steps, each of about the same thickness as the space between them, were ground to their seats in the safe body, the final fit being obtained by grinding for several hours with emery and oil. So accurate was the fit that when the door was closed it was difficult to detect the joint.

It was conceded that the most likely way of forcing the safe was by means of nitro-glycerine. With a blacksmith's cold-set and a sledge, a nick was made, at the upper edge of the closed door, about 1½ ins. long and ⅛-in. deep. A clay cup was molded against the front of the safe in position to run nitro-glycerine into the nick and a charge of ⅛-oz. was fired. This produced an opening of a few thousandths of an inch at the door joint at the nick and for a short distance on each side. The firing was continued with gradually increased charges as more and more of the explosive could be gotten into the crack. As soon as possible, cotton was stuffed into the crack to hold the nitro-glycerine, which was prevented from leaking out at the front by covering the crack with clay.

After the fifth charge (½-oz.), the opening at the nick was .008-in.; after the eleventh charge (1⅛ oz.), it was .052-in.; after the twelfth (4½ oz.), the opening was .067-in., and the whole outer face of the door projected about ⅛-in. It was evident that a large part of the glycerine was leaking through into the explosion chamber where it was less confined and less effective. The 14th charge was 10 oz. and, after it, the door projected 23/32-in. and the crack extended completely around it so that for the 15th charge two clay cups were used on opposite sides of the door and 17 oz. of the explosive were poured in. The explosion of this charge blew off the outer layer of the door and threw the safe over backward.

It was found that the inner part of the door was but little affected. There was a slight opening at the joint for a part of its circumference with a maximum value of about half a hundredth of an inch. The necks which had joined the two parts of the door appeared to have yielded partly to the intense heat of the explosion as well as to its disruptive force. Since the time-lock must have been shattered early in the test, there would now be no way of removing the remainder of the door except by continued blasting.

The safe tested was made by the Ely-Norris Safe Co., of Perth Amboy, N. J. The test was made under the direction of representatives of Robert W. Hunt & Co., of New York City, and the blasting was done by two experts from the Marietta Torpedo Co., of Marietta, Ohio. Assuming that there is no more effective method than that tried for opening the safe, it was proved thoroughly burglar-proof.

THE COMMISSION FORM OF GOVERNMENT has been adopted at Tacoma, Wash., by a popular vote of about 4,000 to 1,000. Under the new charter there will be a council composed of a mayor and four other members elected by popular vote.

A LAND AND IRRIGATION EXHIBITION is to be held at Chicago, Nov. 20 to Dec. 4 for the purpose of representing the opportunities for settlement on the undeveloped lands of the country, and the possibilities of development of the arid and semi-arid lands by irrigation and "dry farming," as well as of the districts where water is abundant or where land must be reclaimed by drainage rather than irrigation. It was organized by a number of railway and land interests and is conducted under the direction of the Chicago "Tribune." The exhibition will be held at the Coliseum, and will cover the agricultural, commercial and technical sides of the development of new areas for settlement. The U. S. Government will have a large selection of exhibits representing the work of various departments, including the Land Office, the Forestry Service, the Geological Survey, the Weather Bureau, the several bureaus of the Department of Agriculture, and (most especially) the Reclamation Service, with its great work of reclaiming the arid regions by irrigation. Land and irrigation companies and the land departments of large railways will have extensive exhibits, and there will be displays of fruit and farm produce. Lectures and illustrated talks on various subjects will be given, and the government department will have a number of moving-picture displays.

THE QUEBEC BRIDGE Board of Engineers has advanced its plans so far that the Dominion Department of Railways and Canals is calling for bids on (1) removing the wreckage of the old bridge, and (2) building the new substructure. The wreckage of the old bridge is to be removed from the shore and down to low water.

THE WASHINGTON, BALTIMORE & ANNAPOLIS R. R. Co. has been put in a receiver's hands, following the failure to pay the interest due on mortgage bonds May 1 last, on which a six months' extension had been granted. It is said by the officials of the road that the failure was due to the payment of certain reconstruction charges out of current earnings. This reconstruction is interesting in that it involves the changing of the motive power of the road from the present alternating to direct current and the substitution of small cars for the extremely heavy and large ones now in service. This road was described in our issue of Feb. 20, 1908, p. 195.

ANOTHER 300-TON LOCOMOTIVE has been built by the Baldwin Locomotive Works, a companion piece to the Southern Pacific freight Mallet described in our issue of April 29, 1909, p. 468. The new engine is for passenger service on the Atchison, Topeka & Santa Fe Ry., and is of the Mallet type. The wheel arrangement is peculiar. The forward frame has a four-wheel leading truck followed by two driving axles. The rear frame has three driving axles followed by a two-wheel trailing truck. The low-pressure cylinders, attached to the forward frame, are abreast of the middle of the leading truck, while the high-pressure cylinders, on the rear frame, are just forward of the leading drivers of this frame. The boiler is separable, as in the Southern Pacific engine, the joint being made just in front of the high-pressure cylinders. Another point of similarity is the intermediate combustion chamber, but in this engine the chamber contains a superheater and a reheater. Forward of this is a feedwater heater. The firetubes back of the combustion chamber are 19 ft. long. The fire gases thus pass first through the firetubes of the boiler, then through the superheater, then through the reheater, and finally through the tubes of the feedwater heater. The superheater takes live steam from the boiler; the reheater takes the exhaust from the high-pressure cylinders; the low-pressure exhaust goes direct to the blast nozzle. The firebox of the boiler is of the vertically corrugated type (Jacobs-Shupert, Eng. News, June 17, 1909, p. 659).

The cylinders are 24 × 38 by 28 ins. stroke. The driving wheels are 73 ins. in diameter. The boiler is 72 ins. in diameter, 19 ft. long in the tubes, and has a firebox 119⅝ ins. long by 63¼ ins. wide, grate area of 52½ sq. ft. The firebox heating surface is 202 sq. ft., the tube heating surface, 4,554, making a total of 4,756 sq. ft. The boiler is designed to carry a pressure of 200 lbs. The wheelbase is: driving, 30 ft. 4 ins.; total engine, 51 ft. 11 ins.; engine and tender, 94 ft. 5½ ins. The length over all, engine and tender, is 104 ft. 11½ ins. The weight on drivers is 268,000 lbs. The engine total is 376,450 lbs., and the total engine plus loaded tender is 600,000 lbs.

The engine is equipped for burning oil. It has an oil tank capacity of 4,000 gals., and a water tank capacity of 12,000 gals.

FOUNDATION INJURED BY SUBWAY CONSTRUCTION is supposed to be responsible for serious cracks which appeared last week in the walls of the Criminal Courts Building, New York City. The building occupies the block between Centre and Lafayette, Franklin and White Sts. The Rapid Transit Subway, built in 1900-1904, extends along Lafayette St., on the west, while a new rapid-transit subway connecting the Williamsburgh and Brooklyn bridges has just been built through Centre St., on the east side of the building. The court-house, constructed in 1891-94, is near the site of the old Collect pond. It has a pile foundation and stone bearing-walls, without steel framework. There have been surmises that the excavation for the adjoining subways loosened the subsoil of the building foundation; also, that the subway excavations and structures by their drainage lowered the groundwater level and exposed the foundation piling. As the Lafayette St. line was built seven years ago and the Centre St. line over a year ago, the second explanation is more plausible.

ENGINE HOUSES AND TURNTABLES.—A committee report to the American Railway Bridge & Building Association gives some figures on the size and cost of engine houses (roundhouses) and turntables for locomotives.

Engine houses on the larger railways are now being built 85 to 90 ft. deep. Some are 92 and 95 ft. deep. Concrete is almost universally used for the foundation walls, and pit walls, in some cases also for the lower parts of the exterior walls, and in a few instances for the entire structure (reinforced). Composition board or wood is favored for the smokejacks, and these are preferably made with large opening. The cost of frame engine houses is quoted in the following examples: Wabash, 42-stall house, $84,500; Lake Shore, 40-stall house, $3,300 per stall; Boston & Maine (brick walls), $1,600 per stall; New South Wales Govt. Rys., 20-stall, $45,000. A reinforced-concrete engine house of the Santa Fe at San Bernardino, Cal., recently built, cost $158,000 for 35 stalls, about twice the average price quoted above.

Turntables on divisions using large engines, especially in mountain country, are recommended variously to be 80 ft., 85 ft. and 90 ft. long. Roads with ordinary

engines require not over 70 ft. or 75 ft. length. Deck plate-girder tables are most widely used, and are preferred except where difficulty of drainage makes through plate-girders necessary. The latter style of table costs more. The cost of turntables is quoted at $4,500 (hand operated, 70-ft., Bangor & Aroostook Ry) to $9,000 (electrically operated, 80-ft., N. Y., N. H. & H. Ry.). The cost of the table itself averages $3,000 to $4,000, the pit, masonry, etc., $3,500, and the power, $1,000. [A wooden hand-operated table has been built for about $1,000, the pit walls also being of wood.] Air motors are used for turning in some cases, but where the air has to be supplied by the engine on the table the operation is too slow. Electric motors are recommended wherever current is available, and gasoline engines for other locations.

Concrete is the preferred material for pit walls and table foundation, except that where a table must be renewed under traffic it is often easier to make the walls of masonry. A solid foundation for the circle rail is important; with a concrete pit wall this is easily provided by an enlargement of the base of the wall.

TESTS OF WOOD FOR PILES.—With a view to furnishing information on the best wood for piles to be used in teredo-infested waters the U. S. Forest Service has planned a series of experiments to be carried out at San Francisco and San Diego, Cal. It is the intention to secure several piles each of all of the species of timber occurring on the Pacific Coast which might be used for pile purposes. This will include different species of eucalyptus, Douglas fir, western yellow pine, western red cedar, redwood, and Lawson cypress (Port Orford cedar). In addition it is the intention to secure Douglas fir piles treated with various preservatives and protective coverings. In the experiments only 8-ft. sections having an average diameter of 10 or 12 ins. will be employed, inasmuch as the cost of handling and transporting larger piles would be prohibitive.

One-half of each kind of timber will be installed at San Francisco and the other half at San Diego. The sections will be fastened to concrete caissons if available. If not, the sections will be fastened to creosoted piles. In such a case they will be so fastened that a space of a few inches will occur between the creosoted pile and the experimental timber. This will guard against any influence which the proximity of the creosoted pile might have on durability. They will be so placed that the upper end will stand about a foot or two above low-water mark.

The ends will be properly protected with asphaltum, copper, or some other suitable substance to guard against the longitudinal attack of borers. Each section will be properly marked with a copper tag for identification. In addition a detailed map will be drawn showing the location of the sections after they are placed in position. In no case will less than six sections of one species be included. The experimental material will be inspected at frequent intervals and reports will be prepared covering the details of the experiments.

Some difficulty is being experienced in securing a sufficient amount of timber for the tests, especially the different species of eucalyptus. Any owners of eucalyptus timber who are willing to furnish a small amount for this purpose should communicate with the U. S. Forest Service, San Francisco. Already several manufacturers of pile casings have signified their desire to have piles treated by their various methods. It is hoped that all such treatments will be well represented.—Bulletin of the U. S. Forest Service.

PRELIMINARY SURVEYS are in progress for the reconstruction of the Welland Canal, to increase its capacity so that the largest lake vessels can pass from Lake Erie into Lake Ontario. The preliminary surveys have shown a possible route for a canal some seven miles shorter than the present route, and with only 7 locks instead of the 25 on the present canal.

UNIFORM STATE LEGISLATION is to be the subject of a conference to be held at Washington early in January, 1910, under the auspices of the National Civic Federation. Among the topics to be considered are conservation of natural resources, corporations, railways, labor, regulation of motor vehicles, good roads, and vital statistics. President Taft has agreed to deliver the opening address.

APPROPRIATION FOR A NEW SUBWAY in New York City was authorized on Oct. 29 by the city's Board of Estimate and Apportionment, after a delay of more than a year, and work will probably be started soon. The new subway is in Brooklyn, extending southerly from the Brooklyn terminal of the Manhattan Bridge, and is known as the Fourth Avenue Subway. The route was fixed and complete plans made by the Public Service Commission two years ago. Bids were called for and contracts awarded, but never executed, the latter because money was not appropriated to carry on the construction. About that time a suit was begun to test the right of the city to begin the new subway work, on the ground that its indebtedness was too close to the constitutional limiting percentage of its assessed valuation. This suit was in substance decided only two weeks ago, as noted in our issue of Oct. 28 (p. 477), and by crediting the city with a substantial margin of borrowing capacity it removed the last ground on which the Board of Estimate might reasonably refuse to appropriate the money needed for the new line. As a beginning, an appropriation of about $3,000,000 was made; the cost of the complete subway is estimated at about $16,000,000.

A constitutional amendment designed to permit further subway construction was voted on in New York State at the election of Nov. 2. This amendment will raise the limiting percentage of bonded indebtedness by exempting from the computation the bonds of self-sustaining enterprises, such as subway lines, leased at a rental sufficient to cover their fixed charges.

A WATER-TUBE-BOILER LOCOMOTIVE has been built by Schneider & Co., of Creusot, France. The boiler consists of a moderate-size upper longitudinal drum and two smaller lower longitudinal drums, connected by 1-in. water-tubes to the upper drum. At the back, along the sides of the firebox, the lower drums are set far enough out to accommodate the brick sidewalls of the firebox between them. The water-tubes curving up to the upper drum form the roof and in part the sides of the firebox. Forward of the firebox the lower drums are set closer together, so that the tubes are substantially vertically except where their ends are bent to make radial connection to the drums. A superheater occupies part of the tube space in the front portion of the boiler. The tubes are enclosed by a casing lined with non-conducting material, so that the locomotive as a whole does not look much different from an ordinary locomotive. The boiler is said to be designed for a steam pressure of 285 lbs. per sq. in. Outline drawings of it are shown in "The Engineer" (London) of Oct. 22, after the "Genie Civil." The locomotive was built for plant service at the Creusot steel works.

THE NATIONAL CONSERVATION ASSOCIATION recently organized, has opened general offices in the Fifth Avenue Building, New York City, with branch offices in Washington. As hitherto publicly announced, the President of the Association is Charles W. Eliot, President Emeritus of Harvard University. The Vice-President is Walter L. Fisher, Esq., of Chicago, well known as the attorney for the city who has carried through to success the negotiations with the street railway companies for the settlement of the long controversy over franchise rights, by the terms of which settlement the city is receiving 55% of the company's gross receipts. The Executive Board of the Association includes, among others, ex-Secretary Garfield, Henry L. Stimson, of New York City; Bernard N. Baker, of Baltimore, and Joseph N. Teal, of Portland, Ore. The Secretary is Mr. Thomas R. Shipp, who acted as Secretary of the Governors' Conference at the White House in May, 1908. A general statement of the principles and policy of the Association, and its plans for work, will shortly be issued.

Personals.

Mr. Urban H. Broughton has been elected President of the Virginian Ry. to succeed Henry H. Rogers, deceased.

Mr. Robt. S. Lovett, President of the Union Pacific Ry., has become also President of the Southern Pacific Ry., succeeding E. H. Harriman, deceased.

Mr. C. M. Levey, Third Vice-President of the Northern Pacific Ry., has resigned that position to become Second Vice-President and General Manager of the Western Pacific Ry., with headquarters at San Francisco, Cal.

Mr. Gaylord Thompson, M. Am. Soc. C. E., Chief Engineer of the Ohio Electric Ry. Co., has removed his headquarters from Cincinnati to Springfield, Ohio, where the general offices of the company have been recently established.

Mr. George W. Davis, Signal Engineer of the Chicago & Alton R. R., has resigned to enter the service of the Railroad Supply Co., of Chicago, and not of the American Railway Supply Co., as erroneously stated in our issue of Oct. 28.

Mr. Jason Paige, Assoc. M. Am. Soc. C. E., formerly Contracting Agent for the American Bridge Co., of New York, at the Chicago office, has become Contracting Engineer for the Lackawanna Bridge Co., 50 Church St., New York City.

Mr. W. C. Steers has been appointed Assistant Master Mechanic of the Cincinnati, Hamilton & Dayton Ry. at Lima, Ohio, to succeed Mr. J. J. Kelker, who has taken a position with the Denver & Rio Grande R. R. at Salt Lake City, Utah.

Mr. Earle J. Banta, M. Am. Soc. M. E., a mechanical engineer in the mechanical division, Isthmian Canal Commission, has resigned to enter business in Cincinnati, Ohio. Mr. Banta sailed from the canal zone for the United States Oct. 19.

Mr. F. D. Nash, Assoc. M. Am. Soc. C. E., who has been for the past two years connected with the construction of the sewers and water-works of Manila, P. I., has been appointed Division Engineer of the Bureau of Public Works, with headquarters at Manila.

Mr. John G. Neuffer, Superintendent of Machinery of the Illinois Central R. R., and the Indianapolis Southern R. R., has been appointed Superintendent of Motive Power of the Chicago Great Western R. R. to succeed Mr. W. E. Symons, who has been assigned to special service.

Mr. William H. Arnold, M. Am. Soc. C. E., formerly Chief Engineer of the Bush Terminal Co. of New York City, and of the firm of Arnold & Andrew, consulting engineers, with offices at 52 Broadway, New York, has become General Manager of the Bay State Dredging Co., 185 Summer St., Boston, Mass.

Mr. Henry B. Seaman, M. Am. Soc. C. E., Chief Engineer of the New York Public Service Commission, First District, has been engaged to supervise the construction of the subway at Cambridge, Mass. During the next two years, Mr. Seaman is to visit Cambridge every Saturday, remaining until the following Monday or Tuesday. This will not interfere, however, with his present position with the Public Service Commission of New York.

Obituary.

Thomas J. Hayward, President of the Bartlett Hayward Co., engineers and founders, of Baltimore, Md., died Oct. 23.

Lemuel Coburn, President of the Coburn Trolley Track Co., died Oct. 26 at his home in Springfield, Mass., aged 79 years. He was the inventor of the Coburn trolley track and of a rag cutter for paper mills.

George T. Barnsley, M. Am. Soc. C. E., President of the Engineers' Society of Western Pennsylvania, died Oct. 23 at his office in Pittsburg, Pa. Mr. Barnsley was born in Montgomery Co., Pa., and was a graduate of the course in civil engineering at Swarthmore College. At the time of his death he was Chief Road Engineer of Allegheny County.

Engineering Societies.

COMING MEETINGS.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Nov. 9-11. Annual convention at Little Rock Ark. Secy., A. P. Folwell, 239 West 39th St., New York City.

NATIONAL MUNICIPAL LEAGUE.
Nov. 15-19. Annual meeting at Cincinnati, Ohio. Secy., Clinton R. Woodruff, Philadelphia, Pa.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Nov. 16. Annual meeting at Washington, D. C., Secy., Martin S. Decker, Albany, N. Y.

AMERICAN RAILWAY ASSOCIATION.
Nov. 17. Annual meeting at Chicago, Ill., Secy., W. F. Allen, 24 Park Place, N. Y.

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS.
Nov. 18-19. Annual meeting at New York City. Secy., W. J. Baxter, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR THE PROMOTION OF INDUSTRIAL EDUCATION.
Dec. 1-3. Annual convention at Milwaukee, Wis., Secy., James C. Monaghan, 20 West 44th St., New York City.

NEW JERSEY SANITARY ASSOCIATION.
Dec. 3-4. Annual meeting at Laurel-in-the-Pines, Lakewood, N. J. Secy., J. A. Exton, 75 Beech St., Arlington, N. J.

AMERICAN SOCIETY OF REFRIGERATING ENGINEERS.
Dec. 6. Annual meeting in New York City. Secy., Wm. H. Ross, 154 Nassau St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual meeting at New York City. Secy., C. W. Rice, 29 West 39th St., New York City.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS.
Dec. 8-10. Annual meeting at Philadelphia, Pa. Secy., J. C. Olsen, Polytechnic Institute, Brooklyn, N. Y.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 14-15. Annual meeting at New York City. Secy., Percy H. Wilson, Land Title Bldg., Philadelphia, Pa.

AMERICAN INSTITUTE OF ARCHITECTS.
Dec. 14-16. Annual convention at Washington, D. C. Secy., Glenn Brown, The Octagon, Washington, D. C.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.
Dec. 27. Annual meeting at Boston, Mass. Secy., L. O. Howard, Smithsonian Institution, Washington, D. C.

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS.
Dec. 28-29. Annual meeting at Ames, Iowa. Secy., L. W. Chase, University of Nebraska, Lincoln, Neb.

MONTANA SOCIETY OF ENGINEERS.
Jan. 6-8. Annual meeting at Butte, Mont. Secy., Clinton H. Moore, Butte, Mont.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—Nominations of officers for the coming year are given in the list prepared by the nominating committee as follows: For President, George Westinghouse, Pittsburg, Pa.; for Vice-Presidents, Charles Whiting Baker, New York City; W. F. M. Goss, Urbana, Ill.; E. D. Meier, New York City; for Managers, J. Sellers Bancroft, Philadelphia, Pa., James Hartness, Springfield, Vt., and H. G. Reist, Schenectady, N. Y.; for Treasurer, Wm. H. Wiley, New York City.